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Joint Research for 2023 KAPEX with the Republic of Ghana

2024. 3.

Ghana Ministry of Food & Agriculture – Seed Inspection Division
Ghana Ministry of Food & Agriculture – Directorate of Crop Services
The Council for Scientific and Industrial Research
– Crop Research Institute
Ghana Irrigation Development Authority
Korea Rural Economic Institute

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제 출 문

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이 보고서를 「2023 국제농업협력(ODA) 정책컨설팅(KAPEX)」 과제의 최종 보고서로 제출합니다.

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Abbreviation

AEA	Agricultural Extension Agent
DADs	District Agriculture Departments
DCS	Directorate of Crop Services
DUS	Distinctivenes, Uniformity and Stability
FDA	Food and Drugs Authority
FRI	Food Research Institute
GhAAP	Ghana Agriculture and Agribusiness Platform
GAPs	Good Agronomic Practices
GRIB	Ghana Rice Inter-Professional Body
GSA	Ghana Standard Authority
GSID	Ghana Seed Inspection Division
ISTA	International Seed Testing Association
JICA	Japan International Cooperation Agency
KOPIA	Korea Partnership for Innovation of Agriculture
MMDA	Metropolitan, Municipal & District Assembly
MoFA	Ministry of Food and Agriculture
NASTAG	National Seed Trade Association of Ghana.
NGOs	Non-Governmental Organisations
NRDS	National Rice Development Strategy
PFJ	Planting for Food and Jobs
PPMED	Policy Planning Monitoring and Evaluation Directorate
PPP	Public -Private- Partnership
PPRSD	Plant Protection and Regulatory Services Directorate
RAD	Regional Agricultural Departments
RELC	Research, Extetnsion and Farmer Linkage Committee
SRID	Statistic Research Information Directorate
WUA	Water User Association

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1 Introduction

1. Research Background

Ghana is capable of achieving rice self-sufficiency, but it is not yet sufficient and still spends a significant portion of its foreign reserves on importing rice from Asia and America. This massive expenditure on rice imports tends to deplete the country's foreign reserves. The funds spent on rice importation could be invested in rice production by developing farm technologies. This, in turn, would create numerous jobs for rural people, significantly transforming Ghana's rural economy in rice-producing areas.

Farmers are encouraged to adopt improved technology and certified rice seeds to boost production and reduce Ghana's import dependency. Adopting any agricultural innovation mainly depends on the complementary roles played by institutions in the provision of credit, education, etc. If the institutions are well-placed to support farmers, innovation adoption will be high and vice versa. In Ghana, institutions such as the Ministry of Food and Agriculture and NGOs, both local and international, are ensuring the promotion and adoption of agricultural innovations.

Through its flagship program, Planting for Food and Jobs (PFJ), Ghana's government has prioritized the production and consumption of local rice. Farmers are encouraged to adopt improved rice varieties as part of this initiative. In short, rice is the second most important staple food, and the demand for rice continues to increase, but a large quantity is still being imported. Consequently, the government has been formulating rice sector development policies and strategies through collaboration with various foreign donor countries and international organizations. Therefore, it is necessary to review the effectiveness of Ghana's rice sector development policies and strategies for improving food self-sufficiency and to supplement the strategy. In particular, one of the main reasons for the low self-sufficiency rate of rice in Ghana is the use of low-yield rice seeds. Thus, this study focuses on the rice seed value chain.

2. Research Objective

The objectives of the study are as follow :

(1) Deriving support policies and institutional improvement proposals for the rice sector in Ghana.

(2) Institutionalizing solutions to mitigate factors hindering the development of high-quality rice seed production.

(3) Identify the current status, problems, and improvement measures of rice production-related technologies in the research area.

(4) Plan international development cooperation projects to improve the dissemination system of rice production technologies in Ghana.

3. Joint research team

For this study, the Korea Rural Economic Institute (KREI) and the Ghana Ministry of Food and Agriculture formed a joint research team of experts in Ghanaian rice seed. From the Korean side, experts from KREI participated, while from the Ghanaian side, experts from the Ministry of Food and Agriculture, the Crop Research Institute (CSIR-CRI), and the Irrigation scheme participated in the joint research.

〈Table 1-1〉 Korea-Ghana Joint Research Team

No	Full Name	Position	Affiliation
1	Maxwell Darko Asante	Deputy Director	The Council for Scientific and Industrial Research-Crop Research Institute
2	Kwasi Wih	Deputy Director	Ministry of Food & Agriculture – Seed Inspection Division
3	Al-Hassan Imoro	Deputy Director	Ministry of Food & Agriculture – Directorate of Crop Services
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7	Ji Yun Park	Research Director	Korea Rural Economic Institute

4. Research Method

4.1. Literature review

Literature review was conducted for the initial data collection, including the analysis of the rice seed value chains in both Korea and Ghana. Documents related to seed policies in Ghana were obtained from the Ghana Ministry of Food and Agriculture. For basic statistical data, information from the Food and Agriculture Organization (FAO) was utilized.

4.2. Field Research

To obtain local information that was difficult to gather through literature review, the joint research team from Korea conducted interviews and collected data from various stakeholders such as the Ghana Ministry of Food and Agriculture, the Irrigation Department, agricultural cooperatives, and seed companies. Local surveys were conducted twice: the first survey took place from May 7th to 14th, 2023, and the second survey was conducted from September 12th to 20th, 2023. Three members of the joint research team from Korea participated in each survey. The detailed schedule and tasks carried out during the local surveys are as follows.

〈Table 1-2〉 2023 KAPEX Ghana Joint Research Field Survey Schedule and Details

Date	Venue	Main Activities
(1st Visit) '23.5.7~5.14	• Ghana Ministry of Food and Agriculture	• Analysis of the current status and problems of the Ghanaian rice value chain through interviews with people in charge
	• Joint research site (Kpeve region)	• Check rice production status and storage facilities by visiting the field (Kpeve) area
(2nd Visit) '23.9.12~9.20.	• Joint research site (Dawhenya region)	• Analysis of the current status and problems of rice seed production in Ghana through interviews with officials such as the cooperative leader and farmers belonging to the cooperative • Analysis of current status and problems from post-harvest management of rice seeds to distribution through interviews with rural guides, seed companies, rice millers, etc., and collection of local data
	• JICA Ghana Office, KOICA Office, KOPIA Office	• Identify the status and status of ODA programs being implemented by other organizations

〈Table 1-3〉 Joint Research Method

Method	Object	Details
Literature Review	• Primary and secondary literature data • Records and statistical data	• Ghana rural development and integrated agriculture-related policies, legislative and strategic framework, etc. • Analysis of reports, documents, etc. for overseas case studies

Method	Object	Details
Commissioned Research	• Conducted commissioned research with four experts from Ghana MoFA, CSIR, and GIDA	• Analysis of rice sector development policies and systems • Institutionalization of measures to resolve factors hindering the development of the high-quality rice seed production sector
Field Interview	• Interview with rice producing farmers' association in Dawhenya region • Interview with MoFA, CSIR, GIDA etc., • Interview with international organizations in Ghana (WFP, JICA, etc.)	• Stakeholder status and problems • Identify current system and problems

2 Strengthening the Rice Seed Value Chain of Ghana

1. Rice Policy of Ghana

Over the past 30 years, rice became one of Ghana's major grains, and consumption has increased rapidly. The rise in population, urbanization, and shifting consumer preferences all contribute to the ongoing rise in rice consumption(Asante et al, 2023). As of 2023, the per capita rice consumption in Ghana was 45 kg, with national demand estimated at around 1.5 million tons. As demand has increased, rice production in Ghana has also steadily increased. However, production has only been able to meet about 50% of the demand until 2022(Asante, 2023). Therefore, the remaining 50% of rice is dependent on imports. With the per capita rice consumption trend in Ghana expected to continue increasing, the government sees increasing national rice self-sufficiency as an important task, as significant costs are incurred annually due to rice imports. Based on this situation, the Ghanaian government, with the assistance of the Coalition for African Rice Development (CARD), formulated the National Rice Development Strategy (NRDS) in 2017, aiming for rice self-sufficiency in accordance with this strategy.

1.1. National Rice Development Strategy

The Coalition for African Rice Development (CARD) is an international organization established in 2008 with the aim of increasing rice production in sub-Saharan Africa, under the leadership of the Japan International Cooperation Agency (JICA). CARD set the goal of doubling rice production in member countries, including Ghana, by 2018 as part of its first phase (2008-2018) strategy. This was implemented through the formulation and execution of Rice Development Strategies (NRDS) tailored to each member country's situation. In the case of Ghana, the first phase of NRDS (2008-2018) focused on improving various stages of the rice value chain, including land, fertilizer, irrigation, and variety improvement (CARD, 2024). Additionally, efforts were made through the "Planting for Food and Jobs (PFJ)" program to improve overall food security, including rice production. Based on these efforts, the first phase of NRDS and PFJ achieved an increase in the production of major staple foods, including rice. Rice seed production has also increased sharply since 2017 (refer to 〈Table 2-1〉).

〈Table 2-1〉 Ghana Rice Seed Production by Seed Stage(by year)

Unit: MT

Stage	2015	2016	2017	2018	2019	2020	2021	2022
Breeder	0.04	0.05	0.53	3.50	4.37	6.52	10.3	12.23
Foundation	8.75	10.20	94.91	616.80	768.50	1,146.60	1,810.90	2,151.30
Certified	578.54	1,231.76	1,866.31	5,203.90	9,021.72	7,746.90	12,917.90	14,124.43

Source: Wih(2023), original data is from internal data of Ghana MoFA-PPRSD.

Since 2019, the second phase strategy of CARD (2019-2030) has been implemented, aiming once again to double rice production in member countries. NRDS 1 in Ghana was revised to NRDS 2, which has been implemented since 2019. In the second phase strategy, not only increasing rice production but also expanding the scale of the rice industry in Ghana, taking into account the country's rice import-export trends, has

been proposed. In particular, the NRDS 2 document summarizes the constraints of Ghana's rice industry and the corresponding strategies as shown in the following 〈Table 2-2〉.

〈Table 2-2〉 Ghana Rice Industry Problem Analysis and Government Strategy by NRDS 2

No.	Problem	Government Strategy
1	• Insufficient supply of certified seeds	• Establishment of rice seed production and distribution system
2	• High cost of farming inputs	• Increasing fertilizer supply and utilization rate
3	• Low post-harvest management technology and absence of marketing system	• Capability: Enhancing post-harvest management and marketing capabilities • Technology: Encourage use of agricultural equipment and support maintenance/repair
4	• Underdeveloped land	• Expand investment in irrigation installation and water resource management
5	• Low human capabilities	• Research, technology development
6	• Land ownership contract system unfavorable to farmers	• Vitalization of farmer organizations and farm credit management

Source: Written by the author with reference to Asante(2023b).

1.2. Planting for Food and Jobs

As mentioned, the Ghanaian government, through the PFJ 1.0 program (2017-2022), aimed to increase not only rice production but also the harvest of major crops, achieving significant outcomes such as GDP growth and increased production of staple foods. PFJ 1.0, in particular, adopted a method of providing subsidies for certified seeds from the national budget to encourage farmers to use certified seeds at a lower cost. While this effectively supplied seeds to farmers, it also had the drawback of being too burdensome on the budget. Additionally, PFJ 1.0 did not encompass the entire agricultural value chain and did not address the pressing issue of low access to credit for farmers. Therefore, based on the lessons learned from PFJ 1.0, the Ghanaian government improved the system and established PFJ 2.0.

PFJ 2.0 is a five-year plan from 2024 to 2028, with the goal of achieving rice self-sufficiency by 2028. The most prominent difference between PFJ 2.0 and PFJ 1.0 is the shift from subsidy programs to improving access to credit, as outlined in 〈Table 2-3〉.

〈Table 2-3〉 PFJ 2.0 Outline

Category	Details
Title	• Planting for Food and Jobs 2.0
Author	• Ghana MoFA and Partner Institutions(AfDB, USAID, World Bank etc.)
Goals	• Achieving the Ghanaian government's agricultural modernization agenda (food security and self-sufficiency)
Specific Goals	• Improved accessibility to farming inputs • Improved agricultural productivity • Food price stabilization • Cultivating commercial agriculture
Main Contents	• Credit Supply System (Input Credit System) • Providing high quality farming inputs and other support services • Establishment of storage facility infrastructure • Arrangement of buyer (sales channel) • Utilization of online platform for business management
Method	• Market-driven approach focused on the private sector • Business management through online platform GhAAP (Ghana Agriculture and Agribusiness Platform)
Difference with PFJ 1.0	• Shift from a direct subsidy method for farming inputs (seeds, etc.) to a method of improving access to credit for agricultural activities. • Market management using distributors (aggregators) • Stakeholder registration and overall business management using an online platform

Source: MOFA(2024).

Like the NRDS 2 document, the PFJ 2.0 document also analyzes the problems in the Ghanaian rice industry and mentions similar contents. However, PFJ 2.0 is a policy document aimed at implementing policies, and it provides more specific policy directions for addressing the issues. In particular, PFJ 2.0 focuses not only on the overall rice industry but also specifically on rice seeds, detailing problem analysis and government support measures, as referenced in 〈Table 2-4〉.

〈Table 2-4〉 PFJ 2.0 Analysis of Ghana Rice Seed Problems and Government Support

Unit: MT

No.	Problem	Government Support
1	• Low accessibility to farming inputs and agricultural machinery - Difficult to use farming inputs (high-quality seeds, fertilizers, etc.) and agricultural machinery due to high costs and low accessibility.	• Improved accessibility to farming inputs and agricultural machinery services - Master Aggregator provides credit guarantee, making it easier for beneficiary farmers to receive loans to receive agricultural inputs and agricultural machinery services.
2	• Insufficient irrigation land and poor water resource management - Of the current rice cultivation areas, only about 10% of the land is properly irrigated. - Decreased productivity due to insufficient irrigation facility management	• Increase rice cultivation area through irrigation land creation - Developing 260,000 ha of agricultural land (including underdeveloped irrigation areas) into irrigation areas - Restoration of facilities in underdeveloped irrigation areas
3	• Inconvenient supply of high-quality, government-certified seeds - (Cause) Inappropriate production and management system, poor distribution environment, etc.	• Support for improved seed production - Support for development of original species and seed varieties through collaboration between the Crop Research Institute (CSIR-CRI) and the Grain and Pulse Development Board (GLDB)
4	• Lack of appropriate storage facilities - Lack of proper storage facilities such as silos - Lack of appropriate processing facilities (dryers, etc.)	• Promoting the construction of storage facility infrastructure - Support for companies interested in storage facility-related businesses to receive long-term, low-interest loans for facility installation
5	(Not applicable*)	• Promote rice consumption - Planning to organize promotional events to promote consumption of domestically produced rice in Ghana

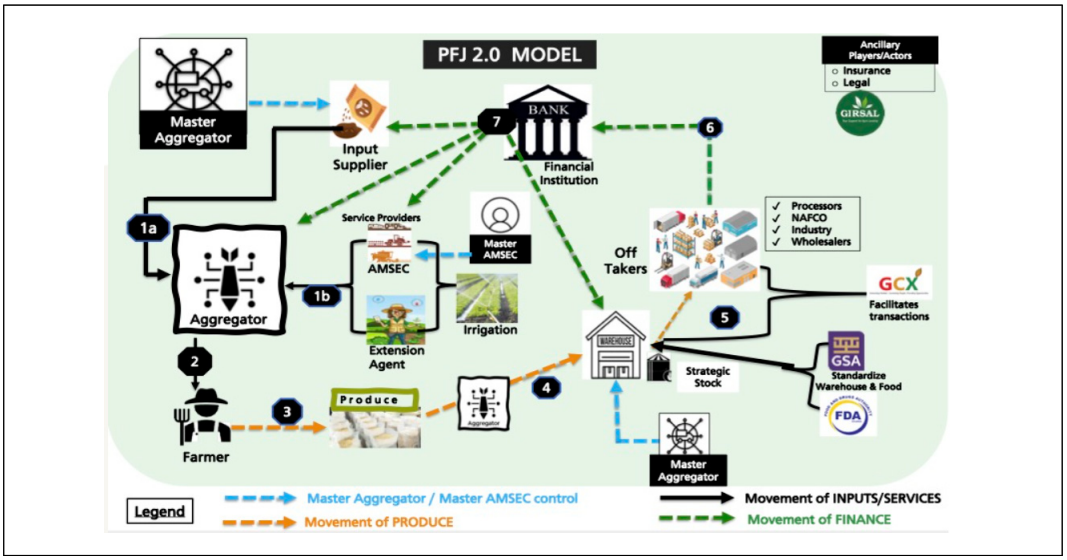
* Note: In the case of Ghana, there is a perception that imported rice is of better quality than domestically produced rice, so the Ghanaian government added the promotion of domestically produced rice to its support list.

Source: Asante(2023b), Original data is from the internal data of Ghana MoFA.

In PFJ 2.0, the government has transitioned to intervene in all stages of the rice industry value chain through a mechanism supporting contract agreements among key stakeholders. For example, the Ghana Ministry of Food and Agriculture designates a distributor (Aggregator) to support beneficiary farmers in purchasing agricultural inputs (such as seeds, fertilizers, etc.) smoothly. The designated distributor provides some guarantees to input suppliers and pre-supplies inputs to farmers. Then, the distributor coordinates settlement at the time of rice sales revenue, allowing beneficiaries to enjoy timely supply of agricultural inputs, machinery

services, etc., with costs incurred in the value chain stages settled afterwards, as illustrated in 〈Figure 2-1〉.

〈Figure 2-1〉 PFJ 2.0 Model



Source: https://ghaap.com/index.php (Accessed: 2024.3.8.).

To facilitate the smooth implementation of PFJ 2.0, the Ghanaian government established an online platform called the Ghana Agriculture and Agribusiness Platform (GhAAP). Through this platform, all beneficiary farmers, seed and crop information, and company details are registered and managed. For farmers who have difficulty accessing the internet, rural extension officers under the Ministry of Food and Agriculture provide support for registration and platform usage.

The Ghanaian government expects that the utilization of GhAAP will not only facilitate the smooth progress of projects but also serve as an effective tool for monitoring and evaluation. Under PFJ 2.0, all transactions related to the project are required to be entered into GhAAP. This allows the Ministry of Food and Agriculture to monitor seed distribution in real-time without direct field inspection. Additionally, various information such as farm output, productivity, and income is collected, which can be used as the basis for future performance evaluations.

2. Rice Seed Production System of Ghana

2.1. Production System

Most Ghanaian consumers prefer Jasmine-styled rice—long grain, aromatic and soft cooking. Thus, most varieties grown by farmers are Jasmine-styled. Even though, over 30 rice varieties have been released, the ones that are widely grown are CRI-AgraRice, Jasmine 85, Legon 1, CRI-Amankwatia, Togo Marshal and CRI-Enapa (Frimpong et al. 2023). More recently, two varieties CRI-Agypa and CRI-KoreaMo registered in 2023 are being disseminated to replace older ones(Asante et al. 2023).

In Ghana, the seed system is divided into formal and informal systems. Ghana's formal seeds are those that follow the quality management system of the Ghana Seed Inspection and Certification Division (GSID) under the Plant Protection and Regulatory Services Directorate (PPRSD) of the Ministry of Food and Agriculture (MoFA), categorized as 'formal' seeds. The informal system refers to all other unregulated seed distribution methods.

The Ghanaian government distributes over 30 rice varieties, with the most widely cultivated being CRI-AgraRice, Jasmine 85, Legon 1, CRI-Amankwatia, Togo Marshal, and CRI-Enapa (Frimpong et al., 2023). In 2023, two varieties, CRI-Agypa and CRI-KOREAMo, based on Korean Tongil rice, were registered at the KOPIA Ghana Center and are also distributed through official channels (Asante, 2023).

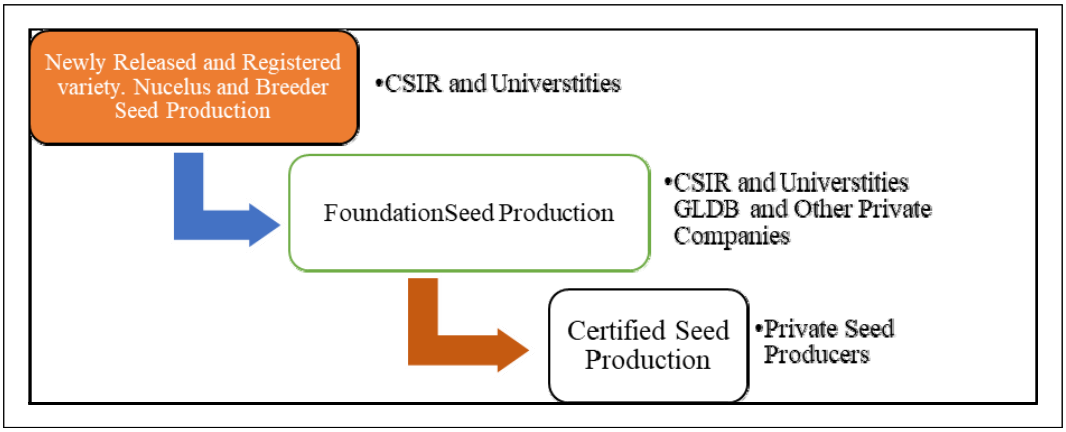
In terms of regulations related to rice seed production, the Plant and Fertilizer Act (Clause 803) was enacted in 2010 (Asante, 2023). This regulation aims to promote and regulate seed production, processing, quality management, and marketing. While the regulation allows private sector participation in the initial stages of seed production, limited private sector capacity hampers smooth participation.

The Ghanaian Seed Law categorizes seeds into three stages: Breeder, Foundation, and Certified. In the case of formal seeds, the Breeder stage, which is the first stage

of seed multiplication, involves variety development conducted in collaboration with international organizations or multilateral technical cooperation bodies by public research institutions or universities such as AfricaRice, the Council for Scientific and Industrial Research (CSIR) under the Ministry of Food and Agriculture (MoFA), specifically the Crops Research Institute (CRI) and the Savanna Agricultural Research Institute (SARI).

For the Foundation stage, private seed companies or farmer cooperatives certified by the Grains and Legumes Development Board (GLDB) under the MoFA are involved in seed production. Unlike in Korea, where Foundation and Breeder stages are distinct, Ghana does not distinguish between these two stages. In the final Certified stage, approximately 400 licensed companies, cooperatives, or individual farmers across Ghana produce seeds. As seed production is outsourced to the private sector, the MoFA strictly regulates breeder registration and conducts field inspections and sample testing at various stages for quality control.

〈Figure 2-2〉 Seed classes in Ghana and organizations in charge of production



Source: Asante(2023).

To release a variety in Ghana, the breeder has to provide a dossier on the varieties to be released to the National Variety Release and Registration Committee (NVRRC). Data on Distinctness, Uniformity and Stability (DUS) and Value for Cultivation and

Use (VCU) is required. The dossier includes at least 12 yield trials in various agro-ecological zones of Ghana in a minimum of two seasons. Data on on-farm trials across the various agro-ecologies is also included. Data on the reaction to the major abiotic and biotic stress is also provided. Physio-chemical and sensory data as well as benefit-cost analysis of the new varieties are also required.

A demonstration field is planted for the NVRRC to inspect the proposed varieties at the vegetative and reproductive stages to validate the data in the dossier. The NVRRC then recommends the accepted varieties to a National Seed Council for ratification. Accepted varieties are published in a National Variety Catalogue and the regional variety catalogue of ECOWAS.

[CSIR-CRI Interview: Regarding Ghana's Rice Seed Production System]

Period: 2023.09.15.

Interviewee: Dr.Maxwell Asante (Deputy Director of CSIR-CRI)

Interview Details

Q. What is the current status of rice production and distribution by the Crop Research Institute of Ghana (CSIR-CRI)?

A. Dr. Maxwell Asante, the interviewee, has been working as a breeder at the Crop Research Institute since 2005 and is currently responsible for the rice breeding team. Since 2005, CRI has developed and distributed over 20 varieties of rice. The institute mainly produces and supplies foundation seeds. Government institutions in Ghana cannot sell certified seeds. Competition between government and market (including private breeders) is legally prohibited. Therefore, public research institutions like CRI are involved only in the production and supply of foundation seeds. Certified seeds are mainly produced and sold by licensed private companies (seed companies), individual breeders, and producer associations.

Q. Where does the Crop Research Institute mainly supply the foundation seeds it produces?

A. Foundation seeds are supplied to entities producing certified seeds (seed companies, individual breeders, producer associations). The majority of the foundation seeds we produce are primarily supplied to seed companies. Some seeds are supplied to the Grains and Legumes Development Board (GLDB). GLDB is the only public institution that receives foundation seeds and sometimes takes basic seeds and parent lines from our institute to produce foundation seeds. Occasionally, when the Ministry of Food and Agriculture in Ghana implements projects, they may take foundation seeds from our institute for new variety demonstrations. The Ministry of Agriculture sometimes directly purchases seeds from our institute. GLDB can be seen as a player in the seed industry rather than being involved in new variety development. They also take basic seeds from our institute to produce and sell foundation seeds. Until the law was revised to allow private companies to produce and sell foundation seeds, GLDB was the only institution producing and selling foundation seeds. However, as they are public institutions, they cannot produce and sell certified seeds.

Q. Cases and experiences of domestic and international collaboration involving the Crop Research Institute.

A. We have collaborated with organizations such as AfricaRice, KAFACI (a project of the Ministry of Agriculture), and recently closely collaborated with Korea's KOPIA center on rice and seed production-related projects. AfricaRice was originally established to support rice variety development and breeding in West Africa, but now its activities have expanded to cover the entire African continent. AfricaRice develops rice varieties and provides them to collaborating countries. They test new varieties in each country and select them according to the conditions and preferences of each country.

Q. Do you receive feedback on the acceptance by farmers and market responses before and after the distribution of certified seeds? How do you assess the demand for seeds annually and seasonally?

A. We distribute varieties based on the preferences of contracted farmers. Although there are no official communication and feedback channels, seed companies that receive foundation seeds from us convey market preferences and demand to suppliers like us by requesting specific varieties. However, there is no system in place to provide accurate data for assessing and predicting seed demand. Most predictions are based on informal feedback or requirements from purchasing companies made by responsible researchers.

Q. How serious do you consider the difficulties and problems in the stepwise production and quality management of seeds regarding seed distribution?

A. The most serious issue in seed production and distribution is related to forecasting. Neither the entities producing nor distributing seeds accurately understand the required quantity and varieties of seeds; they remain at the level of speculation. Furthermore, if there is a lack of budget, manpower, and capacity for demand aggregation and prediction, they simply produce according to the previous year's situation. Financial and technical support is urgently needed for initial generation seed production and demand forecasting. However, the current cooperation projects with Korea through KOPIA are significantly contributing to narrowing the gap in demand forecasting for rice seeds.

Regarding seed distribution, a major problem is that it's difficult for farmers to obtain certified seeds, especially in remote rural areas. Most farmers are used to saving their own seeds, and it's challenging for them to purchase seeds or other agricultural supplies due to the long distances they need to travel.

Additionally, there are concerns about the quality of distributed seeds. Sometimes seeds are not properly tested, or seed sellers mix low-quality seeds with good ones, reducing the trust of rice farmers in the quality of distributed seeds.

Finally, a significant challenge is the lack of facilities and capacity for post-harvest management of seeds, including drying, storage, and transportation. If harvested seeds cannot be sold immediately, they have to be stored for about 6 months to a year, increasing the risk of seed quality deterioration. There is currently a severe

shortage of facilities to maintain the appropriate temperature and humidity nationwide. The operation cost of storage facilities is also a problem. These inadequate facilities and capacity are one of the main factors increasing the cost of seed production.

Q. If seed companies play a major role in producing and supplying certified seeds in Ghana's seed industry, and they are also major buyers of foundation seeds like the Crop Research Institute, do you believe that capacity-building education for seed companies would help in assessing seed demand and improving the capacity for supplying certified seeds to farmers?

A. Yes. Seed companies play a major role in seed production and distribution, and for this reason, AGRA has attempted to establish more of these seed companies with grant aid. These seed companies do not handle only rice seeds. We can share a list of major seed companies that receive foundation seeds from us in the future.

Therefore, including seed companies in capacity-building programs is a good suggestion. Although these companies may not directly contribute to the implementation and success of projects like the K-Rice Belt Project, enhancing the capacity of these seed companies in certified seed production and supplying to farmers can improve the seed distribution system. Moreover, providing incentives to connect major seed companies we deal with and various seed companies nationwide for collaboration could be an effective support measure.

2.2. Problems of Production System

In 2023, the joint research team from the Korea Rural Economic Institute (hereinafter referred to as the "research team") visited rice production areas in Ghana to inspect the situation on the ground. They also conducted interviews with international organizations and stakeholders at various stages of the rice seed value chain, including the KOPIA Ghana Center, to identify real-world problems and seek solutions.

According to an interview with the director of the KOPIA Ghana Center, the rice productivity per unit area in various regions of Ghana is as follows: 2.12T/ha in Central Region, 4.82T/ha in Accra, 5.11T/ha in Volta Region, and 4.02T/ha in the Eastern Region, with an average of 2.96T/ha across Ghana. Imported rice is being sold for about $4.7 to $5.8 per 5kg, while domestically produced rice is sold at an average of $6.7 per 5kg, indicating lower price competitiveness for domestic rice. The director of the KOPIA Center pointed out the following reasons for this low competitiveness: (1) inadequate irrigation facilities, (2) use of low-yield traditional varieties, (3) low mechanization, (4) lack of fertilizer supply, (5) high post-harvest losses, and (6) lack of human capacity.

The research team conducted more detailed investigations into the grievances of farmers by interviewing farmer cooperatives at rice seed production sites in Ghana. In this case, farmer cooperatives refer to Water User Associations (WUAs), which exist within larger cooperatives in Ghana. In particular, in the Dwenya area, there is active exchange within WUAs, so the team conducted interviews with WUAs. According to interviews with cooperative leaders and members, three main issues were identified in the Dawhenya project area: expensive electricity fees, use of low-quality rice seeds, and low mechanization rates.

〈Table 2-5〉 Summary of problems in Ghana's rice seed production system (interview with Farmers' Association(WUA))

Problem	Details
Expensive electricity bills	• In the case of Dawenya irrigation fields, irrigation facilities are operated using water pumps that require a lot of electricity. • In the case of Ghana, there is no subsidy or support system related to agricultural electricity rates. • There is no support system for other management costs (e.g. polishing costs) required by the cooperative other than electricity bills.
Use of low-quality rice seeds	• Low access for farmers to high-quality rice seeds • Currently, farmers mainly use low-yield traditional seeds that they have grown themselves.
Low accessibility to agricultural materials and agricultural machinery	• Currently, in the Dawhenya region, all harvested rice is dried on the ground, which causes the post-harvest loss rate to increase, making the environment especially vulnerable during the rainy season. • Requires drying machine, milling machine, etc. • Currently, fishing nets are used to control pests, so appropriate facilities and pesticide support are needed.

Source: Farmer's Association(WUA) Interview(2023).

Through local interviews in Dawhenya, we were able to identify issues in the post-harvest management stage. In the Dwenya area, processors play a role in post-harvest management and act as intermediaries, so we interviewed them. Processors receive rice from farmers and carry out drying and milling on their own land to assess each farmer's rice production, playing a significant role in the rice value chain. The problems identified by the processors are as follows, as shown in Table 2-6.

〈Table 2-6〉 Summary of Problems in Ghana's Rice Seed Post-Harvest Management System (interview with rice miller)

Problem	Details
Absence of drying facilities	• Rice millers in the Dawhenya region mainly dry rice outdoors, which causes the problem of drying work not being possible in rainy weather, which results in high post-harvest losses. • Recently, the rainy season has been prolonged due to climate change, causing many difficulties in drying work. • Therefore, a drying facility or drying machine is needed.
Low productivity due to low mechanization	• In the post-harvest management and polishing stages, several machines such as separators and polishers are required, but few polishers have all of these facilities.

Source: Dawhenya region rice miller interview(2023).

The issues identified in Tables 2-5 and 2-6 are based on interviews conducted only in the Dawhenya area of Ghana. However, considering literature reviews and commissioned research, it is believed that farmers in other regions also face similar problems.

Furthermore, both farmers and processors commonly emphasized the need for high-quality seeds, which is related to bank loans. When farmers entrust their rice to processors, they often do so after obtaining loans from banks to cover the costs. They repay these loans with the proceeds from the sale of the rice. However, farmers with low rice yields may struggle to repay the loans. Recognizing these issues, the Ghanaian government is focusing on improving farmers' access to credit and the development and distribution of high-quality seeds in PFJ 2.0.

Also from the expert interview,[1] problem of informal seed system of Ghana production system is depicted. Over 50% of rice farmers obtain their seed from the informal seed system. This system is unstructured and unregulated, and characterized by farmer to farmer transfer of seed. There is sometimes no clear variety identification. Thus, this system is fraught with issues with variety identification, seed purity, disease build-up in seed and seed quality issues in general. Besides, it difficult for the authorities in charge of formal seed system to track the activities of the informal seed sector.

Even though, the formal seed sector is regulated, it has many challenges. This includes high dependence on recycled seed, fake/ low-quality seeds, poor seed distribution systems, inadequate technical know-how in rice production, unpredictable weather, high inputs (fertilizer and agrochemicals), insufficient mechanization of field activities, inadequate seed cleaners and dryers, insufficient storage facilities (both cold and ambient), low private industry participation, insufficient funding for seed industry development and inadequate number of seed inspectors.

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1) Dr.Maxwell Asante Interview

[WUA Scheme Manager Interview]

- Period: 2023.09.16.
- Interviewee: Samuel Tetteh (WUA Scheme Manager)
- Interview Details

• (Current Situation) There are a total of 52 irrigation schemes across Ghana, with Dawenya being one of them. Each irrigation scheme, along with the surrounding users, is referred to as an 'irrigation scheme', and the manager of this scheme holds the position of 'irrigation scheme manager' (a civil servant). All irrigation schemes are government facilities managed by civil servants.

• In the Dawhenya irrigation area, there are 251 farmers, including 33 female farmers.

• The Water Users Association (WUA) charges an Irrigation Service Charge for using irrigation facilities and pumps, with more than 90% of the charge being for electricity, and the remainder for facility maintenance. This data is jointly managed by the WUA and responsible civil servants.

[Q&A]

Q. It was said that all users of irrigation facilities must belong to WUA, but I've encountered farmers who are not members of WUA. What are the membership conditions for WUA?

A. All farmers within the project area are automatically considered members. Furthermore, regardless of different WUA groups, all are affiliated under a government-registered 'Federation'. However, there are also farmers who use the water without paying (free riders).

Q. Where and how is WUA managed?

A. WUA is managed by a government agency called GIDA (Ghana Irrigation Development Authority), and all WUAs must be registered within the government system. GIDA provides training for WUAs but does not provide separate subsidies for operational expenses.

Each WUA operates independently. It consists of a management committee of 7 members including a Chairman, Vice Chairman, Treasurer, Secretary, Auditor, etc.,

and members are elected through voting. These committee members do not receive salaries or subsidies from the government; it's an honorary position, and they have an obligation to closely cooperate with government officials. Therefore, members sometimes collect money unofficially from other members.

Currently, the main source of income for WUAs is membership fees paid by members, but there are plans to increase revenue by generating income from machinery rentals, warehouse rents, etc.

Q. Are there any conflicts related to WUA?

A. Yes, there are. Some people are unaware of what WUA does. However, most farmers hope that WUA remains because without it, they fear that projects from the government (international organization projects, rice belt projects, etc.) might be awarded to private companies instead of ordinary farmers.

Q. It's said that companies distribute improved seeds to farmers in Ghana. Could you explain how improved seeds are distributed in detail?

A. The government selects farms to produce foundation seeds, based on criteria such as sufficient land, labor, and water supply. These farms undergo training provided by government agencies to acquire the capacity and qualifications to produce foundation seeds. The government then auctions off these foundation seeds to qualified private companies. This process is mainly conducted through the distribution system of the Crop Services Division of the Ghana Ministry of Food and Agriculture.

Q. Farmers feel burdened by electricity charges; is there a reason for this?

A. The electricity rates are the same nationwide. However, the water pumps used by farmers consume a lot of electricity, which results in high costs proportional to usage.

2.3. Strategy to Improve Production System

To enhance the production and use of certified following are recommended:

1. Production of quality early generation seeds of demand driven varieties.

Breeder and Foundation seed are referred to as Early Generation Seed (EGS). Quality breeder and foundation seed of preferred varieties should be produced and used consistently. It is recommended that in five years, 8.6 MT and 600 MT of breeder and foundation seed are produced respectively to meet to the certified needs of the country. Breeding institutions, the GLDB and selected private sector players with the expertise are expected to produce EGS.

2. Production of quality certified seeds of the demand driven varieties.

Over a period of five years, it is recommended that certified seed production reaches 48,000 MT (Table 5). This will take care of the expected doubling of the area dedicated to rice cultivation in effort to make the country self-sufficient in rice production. Seed entrepreneurs comprising of seed companies and individual seed growers are responsible for certified seed production.

3. Dissemination and promotion of improved rice varieties and production technologies to enhance adoption.

On-farm demonstration fields for the promotion of the improved varieties and good agricultural practices (GAP) should be established in all rice growing communities. In each demonstration field, at least one Field Day should be organized for farmers and other stakeholders in rice value chain. Small seed packs of new varieties that are selected by farmers will be given to them to evaluate on their fields The demonstration fields will serve as a learning platform for farmers and other stakeholders. To help with the dissemination and promotion of the improved varieties and production technologies, Farmer-Based Groups or Innovation Platforms (IPs) will be organized or strengthened (where they exist) in each community. Those

responsible for this activity will include Researchers/ Breeders, Extension staff, Seed companies,

4. Capacity building of stakeholders the rice seed value chain.

Training programmes should be organized to build the capacities major stakeholders in rice seed production comprising of seed producers, input dealers, seed company staff, research staff, extension officers, farmers etc. At least 500 persons including youth and women will trained in rice seed production. While the capacities about 5000 farmers and other value chain actors are built during demonstrations and field days. The Breeding Institutions (mainly CSIR), Ministry of Food and Agriculture (GSID and Extension staff), and Seed Companies will be responsible.

5. Enhanced infrastructure for seed production.

Breeding Institutions have to be supported with dedicated irrigated paddy fields for the production of early generation seed. Other infrastructure required include warehouses, and energy-efficient cold rooms. There is also the need for modern seed processing facilities across the country to facilitate the production of high-quality rice seed.

2.4. Key Findings and Policy Recommendations

Rice is a priority crop in Ghana because it fastest growing food. However, domestic production meets only 50% of the country's rice needs and millions of dollars is imported to take of the shortfall. One of the constraints to achieving rice sufficiency is an under-developed seed industry which is characterized the use of old varieties, lack of essential equipment and infrastructure for seed processing and storage, weak financial and technical capacities of seed companies/ growers, poor seed forecasting and large dependence on an informal seed sector.

To achieve rice-sufficiency, about 48,000 MT of seed is required for cultivation. There is the need to develop up to 600, 000 hectares of paddy to help double the current average yields and increase production to take care of rising demand. Breeders must be supported to develop higher-yielding varieties that are climate-smart. Training of seed growers and farmers is required to improve seed and grain production.

The government must back its vision of achieving rice-sufficiency with policies that will create the needed investment across the rice value chain. The government policy of import substitution should be implemented over a period of 5-7 years with the aim making the country self-sufficient in that period.

3. Rice Seed Certification System of Ghana

Since the implementation of PFJ 2.0 in 2024, government intervention has increased, but Ghana's production system still heavily relies on the private sector. Particularly, from the stage of certified seed production, private entities are entrusted with production under government supervision, making rigorous government oversight essential for seed quality control. However, there is still much room for improvement in quality control and certification from the seed production stage onward.

3.1. Certification System

All inspections and certifications of crops in Ghana, including rice, are conducted through the Plant Protection and Regulatory Services Directorate (PPRSD) of the Ministry of Food and Agriculture. The PPRSD implements pesticide and fertilizer

management, crop quarantine, and crop inspections. With 500 staff members spread throughout Ghana, it is the largest department within the Ministry of Food and Agriculture. Furthermore, both domestically produced and imported seeds in Ghana are subject to inspection. The PPRSD is the most critical department in analyzing Ghana's seed certification system. Therefore, in this study, we conducted a commissioned research with the Deputy Director of the PPRSD and also visited Ghana to interview the staff of the PPRSD, aiming to investigate Ghana's rice seed certification system.

3.1.1. Certification System

The seed quality assurance in Ghana is under the mandate of the Ghana Seed Inspection Division (GSID) established within the Plant Protection and Regulatory Services Directorate (PPRSD) of the Ministry of Food and Agriculture (MoFA) enshrined in the Plants and Fertilizer Act 2010, (Act 803). The GSID operate a National Seed Testing Laboratory (NSTL) at Pokuase, near Accra, and has regional satellite laboratories sited in six locations in the country.

Major functions include:

1. Quality control licensing (registration of seed producers and dealers)
2. Control and monitoring of seed field procedures
3. Post-harvest monitoring
4. Laboratory seed testing and certification annotation
5. Pre and Post Control

GSID follows International Seed Testing Association (ISTA) Rules in its quality assurance management and uses ECOWAS Harmonized minimum standards. The quality standards for seeds propagated by stage are divided into field standards and laboratory standards. There is 6 steps for the quality control and certification.

〈Table 2-7〉 Official Rice Seed Quality Control and Certification Steps

No.	Rice Seed Quality Control and Certification Steps
1	Administrative
2	Verification of seed source
3	Field inspection
4	Supervision at post- harvest stages
5	Seed sampling and analysis
6	Grant of certificate and certification tags

Source: Wih(2023).

When applying for seed certification, verification of the origin and origin of the seeds is conducted. For domestic cultivation sites, comprehensive inspections are conducted on soil hygiene, soil quality, and other growth environments. Packaging inspections are generally conducted four times per planting season. The subject of packaging inspections is primarily managed by the local offices of the Ministry of Food and Agriculture (MoFA) Seed Inspection and Certification Division (GSID), with cooperation from local rural extension officers, local government agricultural departments, and packaging inspection personnel. After packaging inspection, the suitability of post-harvest management is monitored, and seeds that pass inspection undergo laboratory quality testing through sample extraction. If the seed samples meet the quality standards of laboratory testing (purity, vigor, germination rate, etc.), GSID issues a certification and tag for the respective seeds. The average certification rate of the total seed harvest fluctuates between 60% to 80%.

Ghana has various legislation guiding the conduct of the technical and regulatory seed functions. The legislation are as follows:

- The National Seed Policy, 2013
- National Seed Plan 2015
- Plants and Fertilizer Act, 2010 (Act 803)
- Seed Certification and Standards Regulation, 2018 (L.I 2363)
- Plant Protection Regulations, 2012, (L.I. 2193)
- Seed Quality Assurance and Certification Manual.

- Harmonized Seed Regulations-ECOWAS
- Bio-safety Act, 2011 (Act 831) (Regulates GMO process.)

3.1.2. Quality Control System

As indicted previously, seed certification done by the Ghana Seed Inspection Division (GSID) of PPRSD, Ministry of Food and Agriculture. There are three classes of seed comprising of Breeder, Foundation and Certified seeds.

Breeder Seed is the purest form of a variety, produced, controlled, and supplied directly by breeders or their institutions for subsequent multiplication.

Foundation Seed is the progeny of the breeder seed, produced by technical officers in accordance with national standards and handled to maintain the genetic purity and identity of the variety.

Certified Seed is the offspring of the foundation seed, carefully managed to uphold the variety's identity and purity. It is cultivated by seed companies or chosen farmers under specified conditions and certified by the relevant agency. Certified seeds are intended for use in commercial planting.

To produce breeder, foundation and certified seeds of rice in a particular cropping season, the GSID is notified and registration done for the company or individual producer. The GSID would arrange to visit the field before approval for production. During land preparation, planting, vegetative and reproductive phase, and harvesting stage, the GSID would visit and inspect the field. They will also monitor the rice seed processing activities after harvesting. Then, they will sample some of the rice seeds for seed quality testing (purity percentage, viability, vigour, germination percentage & seed health). When satisfied with all the tests, they will certify that class of seed by issuing a certification tag. The breeder seed tag is white with violet strips, foundation seed tag is white with no strips and blue colour is for certified seeds. The seed certification standards used in Ghana is indicated in 〈Table 2-8〉.

〈Table 2-8〉 Ghana Seed Certification Standards

Category	Breeder	Foundation	Certified
Minimum isolation distance (m)	10	5	5
Red rice (white variety) (plants)	0	0	1/100,000
Disease plants (%)	0.01	0.01	0.5
Noxious weeds (%)	0	0	0
Maximum number of plants of other cultivated	0.01	0.01	0.02
Maximum dangerous adventives (%)	0.01	0.01	0.02
Minimum Varietal Purity(%)	99.9	99.9	99.7
Minimum Specific Purity (%)	98.0	98.0	98.0
Minimum Germination (%)	80	80	80
Maximum Moisture content (%)	12	12	12
Maximum number of inert matter(%)	2	2	2

Source: Asante(2023).

3.1.3. Quality Control Feedback

Addressing feedback on rice seed quality control is essential for continuous improvement and maintaining high standards. Below is the approach.

1) Feedback Collection Mechanisms: The Ministry has established clear and accessible channel for collecting feedback from various stakeholders involved in the seed quality control process, including farmers, seed producers, distributors, and quality control personnel. Any issue that emanates from the field is immediately reported to the Zonal Agricultural Extension Officer, who then relays the information to the District/ Municipal Director of Agriculture for appropriate action. Issues beyond the district/municipal levels are sent to the region before the national level if they cannot be addressed at the regional level.

2) Regular Review and Analysis: The 'seed regulators' (who are mainly designated Seed Inspectors of the GSID-PPRSD, with minimum level of tertiary education qualificaton and have undergone the mandatory 3-months in-service seed inspector training) collect and collate feedback systematically using the inspection guide

(protocol). The data is then reviewed and analysed periodically to identify recurring issues, trends, or areas for improvement in the seed quality control system. The inspection protocol is designed to among other things look out for issues (especially of non-compliance), and provide feedback for the necessary corrective measures to be undertaken by clients.

3) Actionable Response: The Ministry of Food and Agriculture promptly acts on feedback and prioritises addressing critical issues affecting or concerning seed quality or distribution efficiency, implementing necessary changes, and communicating improvements to stakeholders.

4) Training and Education: The Ministry uses the feedback to identify gaps in understanding or practices related to seed quality control. It develops targeted training programs or educational materials to address these gaps in stakeholders' knowledge of quality control. The 〈Table 2-9〉 provides summary of trainings and education organized by the Ministry in the last 3-5 years.

〈Table 2-9〉 Summary of training and education sessions organized by MoFA(2019-2023)

No	Training Topic	Types of participants	Venue	Date	Remarks
1	Quality Assurance Training	Registered Rice Seed Producers	Dawhenya Irrigation Scheme	21-22 August, 2023	
2	Rules in certifying Rice seeds				
3	Training of seed producers and inspectors in seed certification and quality assurance		Upper West, Northern, Ashanti		Beginning of the farming season every year

Source: Wih(2023).

5) Engagement and Collaboration: Encourage open dialogue and collaboration among stakeholders. Involve them in discussions to address challenges or implement solutions based on their feedback, fostering a sense of ownership and cooperation.

6) Continuous Improvement: Use feedback as a catalyst for continued improvement. Implement a culture of learning and adaptation, integrating feedback into regular quality control processes to refine and enhance seed quality measures.

7) Transparency and Communication: Communicate the actions taken based on feedback to stakeholders. Transparently share how their feedback has influenced changes or improvements in the seed quality control system.

By incorporating feedback as an integral part of the seed quality control process, stakeholders could identify and address issues proactively, leading to ongoing enhancements in seed quality and distribution systems. The stakeholders' participation in discussing the seed-related problems has created a formidable seed forum /platform organised annually by the National Seed Trade Association of Ghana (NASTAG) to address pertinent seed issues in the country. The table in Appendix 1 outlines the contribution of NASTAG over the years.

3.2. Challenges of Certification System

Several challenges and inefficiencies exist in current seed quality control systems, which include the following:

1) Variability in Testing Methods: Different regions or organisations might use varying testing methods, leading to inconsistencies in seed quality assessment and interpretation of results. For instance, with the ISTA protocols, the GSID undertake the basic seed tests (such as Seed Health, Purity, Moisture and Germination). However, only the GSID at Pokuase Accra is able to undertake the Seed Health test for clients due to the unavailability of the needed equipment at the regions.

2) Limited Accessibility to Technology: Some regions in the country or smaller seed producers might lack access to modern technology for accurate and efficient seed testing, leading to lower-quality assessments. For instance, not all regions in the country do have seed laboratories and qualified seed inspectors who are well equipped with modern technologies to readily assist clients.

3) Cost and Time Intensiveness: Seed quality control tests can be expensive and time-consuming, which may discourage small-scale producers from participating in seed production or delay seed availability.

4) Human Error: Manual assessment of seeds can be prone to human errors, affecting the accuracy of results and the overall reliability of seed quality control systems.

5) Challenges in Detecting Genetic Variations: It can be difficult to detect minor genetic variations or impurities in seeds, impacting the accuracy of purity assessments and potentially leading to unintended crop variations.

6) Storage and Transportation Issues: Inadequate storage conditions or mishandling during sales and transportation can compromise seed quality, leading to inaccuracies in quality assessments. For instance, significant proportion of the seed (input) dealers in Ghana do not have warehouses solely designated for seed storage. The seeds are stored with other pesticides and fertilizers in poorly-ventilated warehouses, containerized shops etc. and the heat generated under these conditions often affect seed quality. Another common practice among seed dealers in open markets is the exposure of packaged seeds to the direct sunlight daily which becomes a routine until the seeds are eventually sold out. The heat generated in the packaged bags on daily basis also tend to compromise the quality of certified seeds.

3.3. Strategy to Improve Certification System

The 〈Table 2-10〉 below illustrates the proposed action/strategies for improving seed quality control.

〈Table 2-10〉 Strategy to Improve Certification System

No	Training Topic	Responsible Insitution
1	Assessment and gap analysis (Conduct a comprehensive assessment of the existing quality control measures in the rice industry. Identify gaps, weaknesses, and areas for improvement in seed production, processing, distribution, etc)	1. Research Team (GSID-PPRSD, DCS, SRID, PPMED)
2	Stakeholders' engagement (Engage all stakeholders—farmers, seed producers, processors, distributors, regulatory bodies, and consumers—to understand their perspectives, concerns, and expectations regarding rice quality)	1. Research Team (GSID-PPRSD, DCS, SRID, PPMED)
3	Define quality standards (Establish clear and comprehensive quality standards for rice, encompassing parameters like purity, moisture content, grain size, milling quality, nutritional content, and absence of contaminants)	1. Research Team (GSID-PPRSD, DCS) 2. Researchers and Academia 3. Government/Regulatory Bodies (GSA, FDA, FRI)
4	Technology integration (Invest in modern technology for quality assessment, such as spectroscopy, DNA fingerprinting, and imaging techniques, to ensure accurate and efficient quality control across the rice value chain)	1. Government and Regulatory Bodies 2. Acadamia 3. Research Team 4. Input dealers
5	Capacity building (Provide training programmes and capacity-building initiatives for stakeholders involved in rice production, processing, and distribution, focusing on adherence to quality standards and best practices)	1. Research/Academia 2. Government and Regulatory Bodies.
6	Quality assurance protocols (Develop robust protocols and guidelines for quality assurance at each stage—seed production, cultivation, harvesting, processing, packaging, storage, and transportation—to maintain quality integrity)	1. Government and Regulatory Bodies 2. Researchers and Academia
7	Monitoring and surveillance (Implement a systematic monitoring system to regularly assess rice quality at various checkpoints. Conduct regular inspections, sampling, and testing to ensure compliance with established standards)	1. Government and Regulatory Bodies
8	Traceability systems (Establish traceability systems utilising technology (e.g., QR codes, blockchain) to track rice from seed to plate, enabling easy identification of the origin and quality of rice throughout the supply chain)	1. Government and Regulatory Bodies
9	Collaboration with research (Partner with research institutions and academia to conduct ongoing research on improving quality control	1. Researchers and Academia 2. Government and Regulatory

No	Training Topic	Responsible Insitution
	methods, developing new testing techniques, and enhancing rice varieties for quality attributes)	Bodies 3. Private sector
10	Public awareness and consumer education (Launch awareness campaigns to educate consumers about quality indicators, proper storage, cooking methods, and the importance of quality-assured rice for health and nutrition)	1. Government and Regulatory Bodies 2. Private sector
11	Pilot programmes and evaluation (Implement pilot programmes to test the effectiveness of the enhanced quality control framework in selected regions. Evaluate the outcomes, gather feedback, and make necessary adjustments)	1. Government and Regulatory Bodies 2. Private sector 3. Researchers and Academia
12	Regulatory alignment (Collaborate with regulatory bodies to ensure alignment of quality control measures with national and international standards, certifications, and trade requirements)	1. Government and Regulatory Bodies 2. Private sector 3. Researchers and Academia

Source: Wih(2023).

The 〈Table 2-11〉 below outlines the expected risks and various mitigation measures to manage the risk.

〈Table 2-11〉 Expected Risks and Mitigation Strategies in Seed Quality Control

No	Potential Area	Expected Risk	Mitigation Strategy	
			Internal Resources and capacity	External cooperation
1	Genetic Contamination or Impurity	Cross-pollination or mixing of seed varieties	Isolation distances between different rice varieties, strict adherence to breeding protocols, and regular field inspections to prevent cross-contamination	Adherence to isolation distances among other measures may not always result in non-contaminated seeds. The use of improved technologies such as PCRs among other may be required to determine true-to-type (genetic purity)
2	Disease and Pest Infestation	Disease or pest outbreaks affecting seed quality.	Regular monitoring, use of disease-resistant varieties, seed treatment, and proper storage conditions to prevent infestation.	Developing capacities in the use of softwares/technologies for diagnosing and managing pests and disease problems. Supporting research into the breeding of disease-resistant varieties. Provision of field diagnostic tools to aid and other laboratory equipment for diagnosis.

No	Potential Area	Expected Risk	Mitigation Strategy	
			Internal Resources and capacity	External cooperation
3	Poor Germination Rates	Low viability leading to reduced germination rates	Regular germination testing, ensuring optimal storage conditions, and proper handling during seed processing and storage.	
4	Storage Conditions and Handling	Inadequate storage conditions leading to seed deterioration.	Controlled storage environments with proper temperature, humidity, and ventilation, along with appropriate packaging and handling protocols.	
5	Quality Control Oversight	Inadquate quality control measures	Implement robust quality control protocols, regular quality checks, and adherence to certification standards.	
6	Regulatory Compliance Issues	Failure to comply with seed quality standards and regulations.	Stay updated with regulatory requirements, maintain meticulous records, and ensure all processes align with set quality standards.	
7	Supply Chain Challenges	Disruptions or inefficiencies in the seed supply chain.	Establish efficient supply chains, maintain traceability, and collaborate closely with suppliers to ensure timely and quality seed delivery.	Establishment of traceability system at the GSID. Building of the capacity of regulators and relevant stakeholders on traceability system.

Source: Wih(2023)

3.4. Key Findings and Policy Recommendations

3.4.1. Key Findings

1) Genetic Purity Assurance: Issues of admixtures, counterfeit and potential genetic erosion of some released varieties. Ensuring genetic purity is crucial to maintaining the desired characteristics of rice seeds. Finding ways to prevent cross-contamination and maintain varietal purity is critical.

2) Storage and Handling Conditions: Inappropriate and deteriorated storage infrastructure located across the regions. Proper storage conditions, including

temperature, humidity, and protection from pests, are crucial to maintaining seed viability and quality over time.

3) Certification and Traceability: Unavailability of robust traceability systems in the rice seed industry. Certification processes and traceability mechanisms are essential to guarantee seed quality, authenticity, and compliance with standards.

3.4.2. Policy Recommendations

Based on the mentioned key findings identified, the corresponding policy recommendations have been proposed as follows:

1) Research institutions, agricultural experts and other industry stakeholders into research should be adequately supported to ensure that the products (varieties) developed and released are of superior quality, with very minimal or no issues with admixtures and less liable to genetic erosion.

2) Seed storage facilities across the regions are currently not fit for purpose. They are inappropriate and have deteriorated. These facilities should be refurbished and equipped with the required equipment to help maintain longevity (or viability) of seeds in storage.

3) Seed traceability system should be developed by investing in testing and certification, strengthening regulatory bodies to implement systems to ensure that seed quality and authenticity is quaranteed.

4. Rice Seed Distribution System of Ghana

4.1. Distribution System

Seed distribution to farmers is primarily done by private companies and seed growers associations selected through competitive bidding. Established companies are most often given allocations regarding what quantities to supply to farmers. The Planting for Food and Jobs (PFJ) Campaign, a flagship programme by the current government since 2017, has implemented a seed subsidy programme to support farmers. Farmers received a 50% subsidy on certified seed purchased at the beginning of the programme. This subsidy was reduced to 25% until 2023, when the government reviewed the programme under the current phase II, dubbed PFJ 2.0, primarily based on an input credit system.

Starting 2024, farmers would receive seeds through assigned aggregators to be paid with produce at the end of every cropping season. These aggregators would be selected by the PFJ Secretariat under the Ministry of Food and Agriculture based on many factors, including the ability to properly store seeds and distribute them to farmers at an agreed price and at the right time. Farmers would be allowed to select which variety of seed they want based on seed availability on an electronic platform named Ghana Agriculture and Agribusiness Platform (GhAAP) which is currently being finalized, would be used for all these processes. The trained Agricultural Extension Agents (AEAs) of the Metropolitan, Municipal and District Assemblies (MMDAs) of the Local Government Service would provide all the needed support to farmers to navigate the platform including registration of the farmers. These AEAs in the various MMDAs have been assigned operational areas (usually of several communities) where they often live and provide technical support to farmers.

4.1.1. Reduction of Government Subsidy

There is no specific budgetary allocation for seed. Still, the budget depends on the quantities of certified seeds distributed by the selected seed companies and seed growers' associations. The government signs contracts with the private companies on specific quantities (quota) based on availability and estimation by DCS and PPRSD. These companies are paid based on the quantities they are able to supply to farmers. The government pays for the portion of subsidies while the beneficiaries pay the rest. However, with the current PFJ 2.0 input credit system will be used, thus famers will no longer have subsidy.

During the initial implementation of PFJ 1.0 (2017-2018), the subsidy rate for seeds was 50%. In 2019, the subsidy rate increased to 75%, but gradually decreased to 20% by the end of PFJ 1.0 in 2022 (〈Table 2-12〉). Subsidy payments were completely discontinued in 2023, and starting from 2024 (the beginning year of PFJ 2.0), a credit supply system will be applied instead of subsidies for seed purchases.

〈Table 2-12〉 Price of Rice Seed under the Ministry of Food and Agriculture Seed Subsidy under the Planting for Food and Jobs Campaign

Unit: GHS/kg

Year	Cost per kg	%	Government Portion	%	Farmers' Portion	%
2017	5.00 (0.43)	100	2.50 (0.22)	50.0	2.50 (0.22)	50.0
2018	7.00 (0.60)	100	3.50 (0.30)	50.0	3.50(0.30)	50.0
2019	8.00 (0.69)	100	6.00 (0.52)	75.0	2.00 (0.17)	25.0
2020	8.00 (0.69)	100	5.00 (0.43)	62.5	3.00 (0.26)	37.5
2021	8.00 (0.69)	100	3.00 (0.26)	37.5	5.00 (0.43)	62.5
2022	10.00 (0.86)	100	2.00 (0.17)	20.0	8.00 (0.69)	80.0

Source: Imoro(2023)

4.1.2. Monitoring of Distributed Seed

The distribution and use of seeds are monitored at various levels: district, regional, and national. The Department of Agriculture) in the various MMDAs ensure that certified seeds reach farmers by verifying the quantities of certified seeds distributed to designated input shops in the district by selected seed companies and seed growers' associations. The District Agriculture Departments through their AEAs also monitor seed sales (distribution) at the various outlets further support farmers with information Good Agronomic Practices (GAPs) on seed usage, including seed selection methods, seeding rate, planting methods, etc. Upon receipt of documentation on the quantity of seeds distributed in a particular district, the Regional Agriculture Department (RAD) under the Regional Coordinating Council (RCC) also verifies the documentation on distributed seeds in that particular district and endorses the documentation for onward submission to the Ministry of Food and Agriculture (MoFA) at the National level for auditing and approval before the payment of the subsidised portion by government.

4.2. Challenges of Distribution System

Improving seed distribution systems requires investments in infrastructure, enhancing storage and transportation facilities, increasing accessibility to information for farmers, promoting diversification in seed suppliers, streamlining regulatory processes, and adopting innovative technologies like digital platforms for better supply chain management. Collaborative efforts between governments, seed producers, NGOs, and agricultural organisations are crucial to addressing these challenges and ensuring equitable access to quality seeds for farmers. Nonetheless, Ghana has various challenges, and the challenges are as follows:

1. Limited Access: Some regions, particularly remote or underserved areas in the Western North and Oti regions struggle with limited access to quality seeds due to poor infrastructure, inadequate distribution networks, or economic constraints. Most farmers in the seed production areas like Northern, Greater Accra, Ashanti, Upper East Regions etc have better access due to proximity than others.

2. Inefficient Supply Chains: Inadequate transportation and storage facilities can lead to delays, damage, or spoilage of seed stocks, affecting their quality and viability upon reaching farmers.

3. Insufficient Information: Some farmers lack information about the availability of suitable seed varieties, optimal planting times, or proper seed handling techniques, impacting their choices and crop outcomes. This is mainly due to the limited number of Agricultural Extension Agents (AEAs), poor internet access, poor road network, etc. thus, affecting the timely delivery of information to farmers adequately.

4. Market Concentration: Dominance by a few large seed suppliers may limit diversity and access to a wide range of seed varieties. This concentration can sometimes restrict farmers' options and lead to dependency on specific varieties.

5. Quality Control During Distribution: Ensuring seed quality during transit and storage is challenging. Poor handling practices during distribution can compromise seed viability and performance.

6. Regulatory Hurdles: Complex regulatory requirements and bureaucratic procedures may hinder the smooth flow of seeds across borders or within regions, causing delays and increased costs. Sometimes, seeds may have to be received and approved in the regions, districts before being sent to farmers to ensure the farmers received the seeds in the best conditions and this sometimes delay the receipt of the seeds by farmers.

7. Climate Change Impact: Climate change can affect seed distribution by altering planting seasons or rendering certain seed varieties unsuitable for specific regions due to shifting climatic conditions.

Infrastructure challenges, such as inadequate transportation networks and storage facilities, can cause delays and quality deterioration during seed distribution. Quality assurance issues arise from inconsistencies in seed quality control measures across the distribution chain, leading to the circulation of substandard or contaminated seeds. Additionally, an information gap exists, with limited farmer awareness about available seed varieties, their characteristics, and the importance of using quality seeds, hindering their adoption and effective utilization.

4.3. Policy Recommendations

To address these challenges, fostering collaborations through public-private partnerships involving public institutions, private seed companies, NGOs, and farmer cooperatives can enhance seed development, storage, and the efficiency of distribution networks, ensuring timely access for farmers. Additionally, establishing and enforcing stringent quality standards for rice seeds is crucial, ensuring that certified seeds meet defined criteria for purity, viability, and performance. Moreover, investing in farmer education programs to raise awareness about the importance of using quality seeds, proper seed handling, and best agricultural practices is essential for building capacity and improving overall agricultural productivity.

[Dawhenya Region Agricultural Extension Officer Interview]

- Period: 2023.09.16.
- Interviewee: Dominic Jawah (Extension Officer)
- Interview Details

Q. Could you provide a brief self-introduction?

A. I have been working as a civil servant at the Agricultural Technology Center in the Dawenya area for nine years, mainly focusing on empowering farmers. Capacity building is mainly conducted in a Train-the-Trainer (TOT) format, targeting farmer leaders. Selection for TOT prioritizes farmers who can disseminate skills to other farmers. Additionally, I visit farms directly to assess the situation.

Q. Could you provide additional information about the farm visits?

A. There are a total of eight staff members at the Agricultural Technology Center in Dawenya, with only one being female. Dawenya has a relatively large staff count compared to other areas. In other regions, each agricultural extension officer (similar to Korea's rural extension agents) has to cover around 3000 farmers, which means most farmers do not benefit properly from agricultural technology centers. Farmers can communicate with extension officers via WhatsApp (similar to KakaoTalk group chats) and there are WhatsApp group chats for online communication. Dawenya is particularly advantageous as it has four agricultural input suppliers within the area, making access easier for farmers compared to other regions.

Q. Where do the staff members of the Agricultural Technology Center receive their training?

A. The training is conducted by the Ministry of Food and Agriculture. It targets agricultural extension officers spread across Ghana. For production-related matters, the training is conducted by the Plant Protection and Regulatory Services Department, and for distribution-related matters, it's conducted by the Crop Services Department. Sometimes, the training is conducted by local authorities, and in 2023, we were able to receive training about four times. All these trainings

are government-funded, so civil servants attending don't need to pay separately. Additionally, there are trainings conducted by international organizations, private companies, etc. JICA and KOICA have also conducted training sessions.

Q. As a civil servant at the Agricultural Technology Center, what are some challenges you face?

A. Firstly, there's an issue with transportation when visiting farmers. Although motorcycles are provided, the roads in some areas are not good, and continuously using motorcycles to visit farms is risky, with no insurance coverage provided. Providing cars instead of motorcycles would be helpful, but it seems impractical. Also, there's a need for more frequent training on the latest agricultural technologies, but the government's budget is limited, and civil servants also have limited time.

5. Rice Farmer's Access to Agricultural Inputs

Through the commissioned research, the joint research team tried to figure out the status of farmers' access to agricultural inputs. With the support of Ghana Irrigation Development Authority, the Ghana joint research team(led by Samuel Tetteh) could obtain the survey result of Ghana rice farmers' access to input status and their challenges.

5.1. Summary of Findings

The regions considered are Greater Accra, Volta, and Western regions. The farmers interviewed were from Ningo Prampram, Shama, Ashaiman, north Tongu and Ketu South. Forty rice farmers were originally scheduled to be interviewed, but

twenty-four completed the survey. Four extension agents were also interviewed. Descriptive statistics were utilized in the data analysis, revealing a discernible level of adoption of certified rice seeds. However, some rice farmers still need to embrace the innovation. The study showed that the high cost of certified rice seeds and the high cost of tractor services is another challenge confronting rice farmers.

The results revealed that there is a higher acceptance rate for the use of modern equipment such as harvesters and threshers. The results show that most farmers rely on hiring harvesters and threshers.

It is revealed that improved technology and affordable agro-inputs are some of the forces that drive rice farmers into the adoption of technology. The results showed that most of the rice farmers interviewed had access to extension services. Access to farm credit, the results showed that there is a general lack of access to credit and an unwillingness of financial institutions to grant credit to farmers. Most rice farmers interviewed indicated that access to farm credit is their significant challenge hence their inability to adopt innovations. Aside from the high cost associated with tractor services, access to tractor services is a challenge for some rice farmers. The study revealed a few factors which are peculiar to the adoption of certified rice seeds, but the key factors are the unavailability of certified rice seeds, non-viability, and the high cost of certified rice seeds. For government-specific programs towards the promotion of the adoption of certified rice seeds, the farmers rated them as highly ineffective.

On the challenges associated with collaboration between extension agents' institutions and international institutions, it is revealed that lack of frequent visits by regulators due to lack of funds, lack of funding to organise training for farmers and weak link, delay in response, inadequate logistic are negatively affecting collaborations hence impacting negatively on the certified rice seed adoption.

5.2. Survey Results

〈Table 2-13〉 shows the distribution of rice farmers who do not use certified rice seed across the the districts and regions. The results show that, they are mainly from Greater Accra and Volta region.

〈Table 2-13〉 Regional and District Distribution of Farmers who do Not Use Certified Rice Seed

Region	Ashaima Municipal	Ketu North	Ningo Prampram	North Tongu	Total
Greater Accra	4	0	1	0	5
Volta	0	3	0	2	5
Total	4	3	1	2	10

Source: Tetteh(2023).

The mean age of rice farmers who do not use certified rice seed is approximately 53 years with a minimum and maximum years of 40 years and 79 years, respectively. Their average farm size is 2.6 acreage with a minimum of acreage of 1 and maximum acreage of 4. The average years of experience in rice production is 13 years with minimum and maximum years of experience been 5 years and 25 years, respectively. For fertilizer applications, average fertilizer usage per acreage for farmers who do not use certified rice seed is approximately 6 bags with minimum and maximum usage per acreage of 1 bag and 20 bags, respectively. The average rice yield per acreage (50kg bag) is 45 with minimum and maximum been 12 and 80 bags, respectively.

〈Table 2-14〉 Socioeconomic Characteristics of Farmers who do Not Use Certified Rice Seed

Variable	Obs	Mean	Min	Max
Age	10	52.5	40	79
Farm size	10	2.6	1	4
Experience	10	13	5	25
Fertilizer (Quantity)	10	5.6	1	20
Yield (Per acreage)	10	45.3	12	80

Source: Tetteh(2023).

〈Table 2-15〉 shows the regional and district distribution of rice farmers who use certified rice seed. The results show that most of them are from Shama district in Western region. Some of them are also from Greater Accra region thus Ningo Prampram. Compare to rice farmers who do not use certified rice seed, there are no rice farmers who do not use certified rice seed per the sample analysed.

〈Table 2-15〉 Regional and District Distribution of Farmers who Use Certified Rice Seed

Region	Ashaima	Ningo Prampram	North Tongu	Shama	Total
Greater Accra	1	4	0	0	5
Volta	0	0	3	0	3
Western Region	0	0	0	6	6
Total	1	4	3	6	14

Source: Tetteh(2023).

〈Table 2-16〉 presents results on farmers socioeconomic characteristics. The mean age of rice farmers who use certified rice seed is approximately 54 years, which is greater than the mean age for farmers who do not use certified rice seed. The minimum and maximum years are 24 years and 70 years, respectively and are less than the minimum and maximum years of the rice farmers who do not use certified rice seed. For farm size, rice farmers who use certified rice seed average farm size is approximately five acreages, which is higher than farmers who do not use certified rice seed. The minimum and maximum farm size are 1 and 14 acreages, respectively. The maximum farm size for those who use certified rice seed is greater than those who do not use certified rice seed. The results further show that the average years of experience for rice farmers who use certified rice seed is 14 years and greater than those who do not use certified rice seed. The minimum and maximum years of experience are 5 years and 47 years, respectively, with the maximum years of experience for the rice farmers who use certified rice seed greater than those who do not use certified rice seed.

On the yield per acreage, the results show that the average yield per acreage is

approximately 56 bags (50kg size). The minimum yield and maximum yield are 30 and 90 bag (50kg size) per acreage, respectively. Both the minimum yield and maximum yield for rice farmers who use certified rice seeds are greater than the minimum yield and maximum yield for rice farmers who do not use certified rice seed. This goes to affirm the importance of using certified rice seed. For fertilizer applications, average fertilizer use per acreage is approximately 6 bags, which is not different from farmers who do not use certified rice seed. The minimum and maximum fertilizer application are 3 and 13 bags per acreage, which is lower than the farmers who do not use certified rice seed rate of application.

〈Table 2-16〉 Socioeconomic Characteristics of Farmers who Use Certified Rice Seed

Variable	Obs	Mean	Min	Max
Age	14	53.8	24	70
Farm size	14	5.3	1	14
Experience	14	20.4	5	47
Yield (Per acreage)	14	55.7	30	90
Fertilizer (Quantity)	14	5.6	3	13

Source: Tetteh(2023).

〈Table 2-17〉 represents the results of challenges that rice farmers face in obtaining and using certified rice seeds. Though rice farmers have been given a catalogue of challenges that they are confronted with in obtaining and using certified rice seeds, the unavailability of certified rice seeds on the market is rated the major challenge with a percentage score of 45.45. The results further show that viability is a challenge confronting farmer in obtaining and using certified rice seed as 13.64 indicated is their main challenge. The cost of procuring certified rice seeds is another challenge that confronts rice farmers. 9.09 per cent of the farmers interviewed indicated that costs hinder their ability to adopt certified rice seeds.

〈Table 2-17〉 Challenges in Obtaining and Use of Certified Rice Seeds

Challenge Type	Freq.	Per cent	Cum.
Accessibility, affordability	1	4.55	4.55
Very expensive	2	9.09	13.64
Distance in buying, funds	1	4.55	18.19
Distance to obtain certified seeds, unavailability.	1	4.55	22.74
Distance to obtain certified seeds, irregular supply, poor quality	1	4.55	27.29
Limited supply, high price	1	4.55	31.84
Mature earlier than expected but with empty pods	1	4.55	36.39
Non-Viability(Re-use own seeds for planting)	3	13.64	50.03
Price and quality source	1	4.55	54.55
Unavailability	10	45.45	100
Total	22	100	

Source: Tetteh(2023).

〈Table 2-18〉 shows the results of the challenges rice farmers are confronted with. The results show that high interest rates and lack of credit are rice farmers' significant challenges, recording 29.4 per cent. The unwillingness of financial institutions to grant credit to rice farmers is another challenge facing them, with a score of 17.64 per cent. Complex banking processes are another challenge that rice farmers are facing in trying to secure farm credit.

〈Table 2-18〉 Challenges Faced by Rice Farmers

Challenge Type	Freq.	Per cent	Cum.
Complex banking processes	2	11.76	11.76
High interest rate	5	29.41	41.18
Financial institutions' unwillingness to grant credit	3	17.65	58.82
Unavailability of inputs	1	5.88	64.71
Unavailability of financial institutions	1	5.88	70.59
Lack of credit	5	29.41	100
Total	17	100	

Source: Tetteh(2023).

5.3. Policy Recommendation

The study shows that farmers access to agricultural inputs can be achieved through credit facilities and good national agricultural policy target, which provides safety net for small scale rice farmers. Inability of rice farmers to fully embrace the innovation in rice production sector is partly due to the cost of certified rice seeds, cost of inputs, and labour cost. It is further revealed that often certified rice seeds are not viable as they fail to germinate when planted. High cost of certified rice seeds is another challenge impacting negatively on the use of certified rice seeds.

For general challenges faced by rice farmers, lack of credit, unwillingness of financial institutions to grant credit to farmers, high interest rate and complex banking processes are rated as some of the major challenges. On the effectiveness of government's programs in addressing rice farmers challenges, rice farmers rated those programs as been highly ineffective and ineffective.

It is revealed that some of the innovations that farmers are encouraged to adopt are not suitable in the local farmer's condition as some are not financially sound to embrace such technologies as they come at accost in terms of inputs requirement. Also, some of the collaborations with the international institutions are within short period of time, which makes it difficult to realize their benefits in full.

To address the high cost of certified rice seeds on the market, government and relevant stakeholders should collaborate in implementing an effective system of certified rice seeds delivery to farmers. Absence of an effective certified rice seed delivery may cause middlemen to exploit the system. Since affordability of certified rice seed is a concern for rice farmers there is the need to introduce subsidies or financial incentives to make certified seeds more affordable for farmers. This will reduce the financial burden associated with their adoption. Also, there is the need to establish seed banks or cooperatives that provide easy access to certified seeds, ensuring their availability in remote or rural areas.

It must be acknowledged that addressing the non-adoption of certified rice seeds or encouraging its adoption is a multifaceted task that requires collaboration among government agencies, agricultural extension services, research institutions, NGOs, and the private sector. To achieve this, there is the need for the actors to collaborate in mass production of certified rice seed for farmers. The actors should also collaborate to ensure that certified rice seed is always affordable and available for rice farmers.

3 Rice Seed Value Chain in South Korea

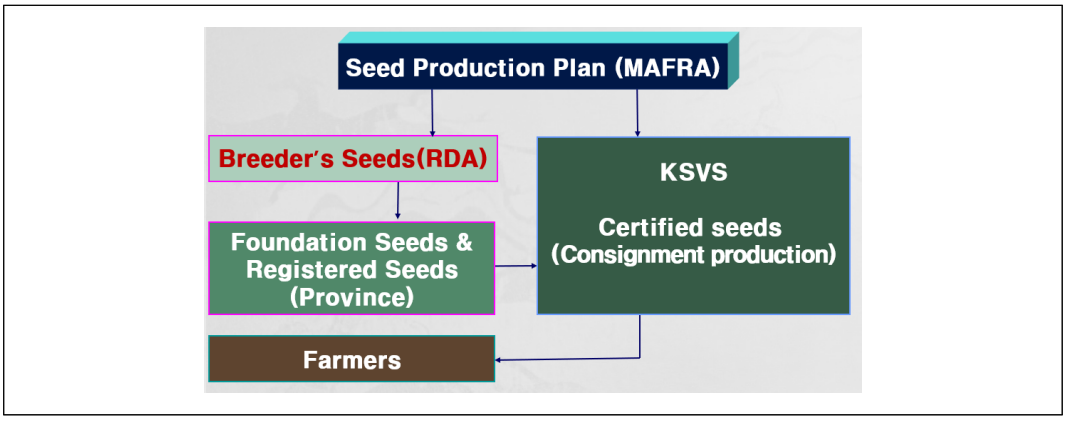
1. Rice Seed Production of South Korea

The effects of seed renewal are multifaceted and crucial for maintaining agricultural productivity. Firstly, the exchange with a new elite variety helps introduce improved traits and characteristics, enhancing overall crop performance. Secondly, seed renewal plays a vital role in maintaining seed purity by preventing genetic deterioration. This involves measures such as preventing natural cross-pollination, separating new genetic variations, and mitigating the risk of mutation or mechanical admixture of heterogeneous seeds. Additionally, seed renewal is essential for preventing physiological deterioration resulting from continuous cultivation, as well as pathological deterioration caused by various pests and diseases, including leaf blast, bakanae disease, and viruses. Ultimately, by preventing harvest reduction due to seed deterioration from on-farm seed production, seed renewal ensures consistent and reliable crop yields for farmers.

1.1. Production System

The production process for major food crop seeds comprises four primary stages in South Korea. Initially, institutions such as the Rural Development Administration breed varieties like rice and annually produce basic seeds. Foundation seeds, possessing unique characteristics of each variety and serving as the basis for seed multiplication, are produced by Agricultural Technology Institutes. Breeder seeds, resulting from first-generation multiplication of foundation seeds, are produced at provincial breeder seed farms. Certified seeds, derived from breeder or foundation seeds after first-generation multiplication, are then supplied to farmers. Thus, it takes approximately four years for certified seeds to reach farmers.

〈Figure 3-1〉 South Korea's Seed Production Stakeholders



Source: KSVS(2024a).

Government-supplied species are produced by consignment of seeds under a contract between the KSVS(Korea Seed & Variety Service) and the contract farmers. The selection criteria for the contract farmer is as follows: (1) Having history of growing the crop for 3 years or longer, and (2) Managing seed-producing fields clearly and separately. More importantly, the field also needs to meet the criteria: (1) Suitable for crop growth (fertile, bright, aircirculation, etc.), (2) Not frequently

affected by pests and floods, (3) Conducive to irrigation and filed isolation, (4) Possible for bulking (rice 30ha, previous crop 20ha), (5) One variety per field(if not possible then 2 varieties). If the farmer and the field meets the criteria, they will be selected as a seed farmer. Then, the farmer will receive an additional 15-20% of the purchase price as a production incentive only for the quantity that passed the seed inspection.

1.2. Field Management

Once the contract farm is selected, Korean government(RDA and KSVS) manages the contracted fields to ensure the rice seed quality. Confirmation of the authenticity of the variety crucial. It is the process of ensuring that the characteristics of the variety are properly expressed. The Inspection is consucted during the growing season when the unique characteristics of rice seed can be best identified. The field inspection and management is done as the following steps:

1. It is necessary to reduce fertilizer usage compared to regular farms to prevent crops from falling. In particular, for rice, we manage not to exceed 70% of the fertilizers used by regular farms.

2. Conduct pest control measures primarily on a preventive basis by constantly observing whether pests occur in each field.

3. From the growth regeneration period to just before harvest, any heterogeneity such as hybrid strains or different varieties are promptly removed upon discovery.

4. A series of operations including seed disinfection, sowing, and pest control are managed by implementing a production history system for each plot.

5. Collaboratively with variety breeding institutions, seed production institutions, and seed sources, the seed growing process is verified.

6. Seed inspections such as seed quality, germination rate, and purity are conducted.

7. Furthermore, precise management is conducted through the installation of test beds tailored to each field.

The field is inspected during the growth of each crop. The variety uniformity, weed standards, and pest inspection are conducted. The field inspection standards are as follows.

〈Table 3-1〉 Field Inspection standards

Minimum(%)	Maximum(%)					
Purity	Other Seeds	Weeds		Diseases		Growth
		Specific	Others	Specific	Others	
99.7	None	0.01	None	0.02	20.00	Uniform

Source: KSVS(2024a).

For seed harvest, the timely harvest is considered according to various conditions such as weather, moisture content, etc. The seed moisture should be 19-21% for rice seeds.

1.3. Seed Management

For rice, it is crucial to thoroughly disinfect the seeds to prevent diseases that can be transmitted through seeds. In Korea, one of the major concerns related to rice seed supply is bakanae disease. Bakanae disease abnormally enlarges the roots of rice plants, reducing rice production and affecting farmers' income. Therefore, diseases including bakanae disease are strictly managed.

Recently, the hot water treatment method, which has been shown to be highly effective against seed-transmitted diseases, is mainly used. The seeds are immersed in hot water at 60℃ for precisely 10 minutes and then immediately removed and cooled down with cold water. This process effectively eliminates bakanae pathogens

on the surface of the seeds. Next, the seeds are soaked in seed disinfectants for about 24 to 48 hours and simultaneously sprouted. This simultaneous treatment ensures both seed disinfection and germination.

Once the hot water treatment is completed, the seeds are subjected to chemical disinfection to eliminate foot rot pathogens that may be present inside the seeds. During chemical disinfection, it is important to pay attention to the correct concentration of the disinfectant. To achieve this, water is first added to the seeds for germination, and then the disinfectant is added. To ensure that the disinfectant penetrates well into the seeds, the germination temperature is maintained at 30-32°C for 48 hours during the soaking disinfection process. Moreover, it's essential to ensure that the seeds are adequately submerged in water.

After proper treatment, the seed inspection is conducted by KSVS. The purity and germination rate are inspected.

〈Table 3-2〉 Seed Inspection Standards

Minimum(%)		Maximum(%)					
Pure Seed	Germination Rate	Moisture	Other Varieties	Other Seeds	Damaged Grain	Inert Matter	Nonglutious Rice
98.0	85	14.0	0.10	0.05	3.0	2.0	0.6

Source: KSVS(2024a).

2. Rice Seed Certification of South Korea

2.1. Related Law

There are three related law and regulations regarding the rice seed inspection. First is the "Seed Industry Act", the second is "Seed Management Guideline" and the last is "Seed Inspection Method"(KSVS, 2024b).

Production, inspection, and supply of high-quality seeds in compliance with the standards and methods set forth by relevant laws and regulations. Seeds that pass inspection are guaranteed, with both national and self-guarantee systems in place. Seeds inspected by the Ministry of Agriculture, Food and Rural Affairs are considered to be guaranteed by the government, while those guaranteed by private seed managers are considered self-guaranteed. The crops supplied through national guarantee include major food crops such as rice, barley, and soybeans. It's worth noting that while Korea adhere to the methods of the OECD Seed Scheme, Korea have also implemented enhanced management standards tailored to the Korean context.

2.2. Certification Procedure

The rice seed certification system is operated throughout the whole rice seed production procedure. It is started from field inspection. KSVS operates a guarantee system for seeds to maintain consistent quality throughout the production and supply process. To ensure seed quality, we conduct packaging inspections (on-site inspections), seed inspections, and seed guarantees before supplying seeds to farmers. Through packaging inspections, seed inspections, and our guarantee process, we supply seeds to farmers with assurance of quality. The process can be simplified as 6 steps: (1) Field Inspection, (2) Harvest Testing, (3) Purchasing (Stocking), (4) Seeds Cleaning and Selection, (5) Seeds Inspection, (6) Post Testing.

During the field inspection, various standards are applied. For example, field isolation should be more than 1m, 2m, 3m by production stage from a different variety. The condition of field should meet the following three conditions: ① The source of the seed sown must be clear, ② More than a third will not fall over(Except when it does not interfere with growth and fruition), ③ When weeds are generated enough to prevent.

There are three seed stages that are grown by KSVS and the inspection standards differ by stages. The following table represents the standards.

〈Table 3-3〉 Seed Inspection Standards by Seed Stage

Category		The lowest Limit(%)	Highest Limit(%)					Growing Conditions
		Breed Purity	Other Seeds	Weeds		Disease		
				Harmful Weeds	Weeds	Specific disease	Other Disease	
Basic Seed		99.9	0	0	-	0.01	10.0	Uniform
Foundation		99.9	0	0	-	0.01	15.0	Uniform
Certifed Seed	1st Generation	99.7	0	0.01	-	0.02	20.0	Uniform
	2nd Generation	99.0						

Source: KSVS(2024b).

The field inspection specifications for rice in the seed inspection regulations are divided into categories such as Basic, Foundation, and Certified species (1st generation, 2nd generation), with stricter standards applied as the level increases. The seed purity, particularly for the original species, is extremely high at 99.9%. There should be no other seeds of different varieties, and criteria for harmful weed or pest contamination are also defined.

〈Figure 3-2〉 South Korea's Field Inspection

Source: KSVS(2024b).

After the field inspection, the certified seeds will be harvested and put into next inspection level. After the KSVS purchase the seeds, they conduct detailed tests on variety purity, germination rate, damaged grains, etc.

3. Rice Seed Cleaning and Selection of South Korea

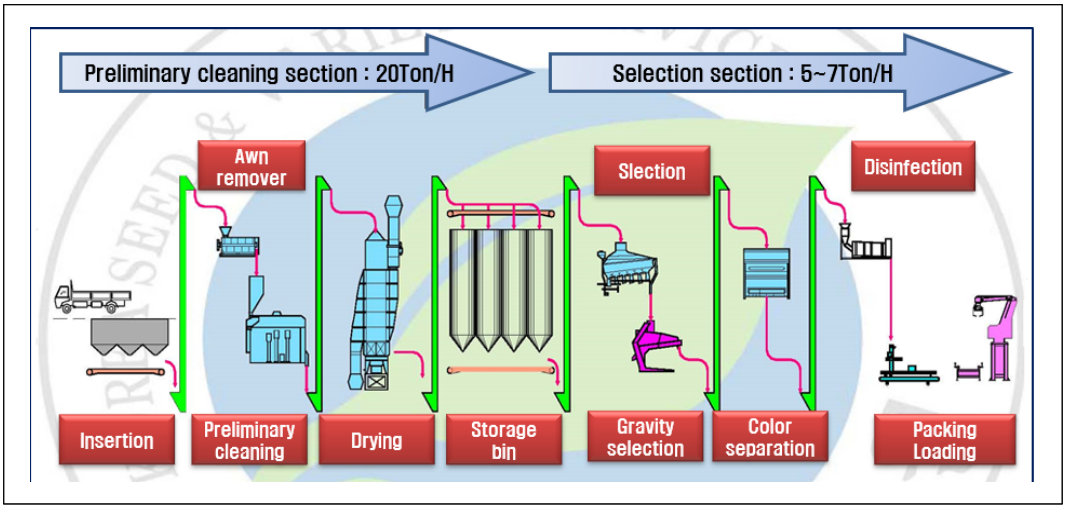
3.1. Purpose of Seed Cleaning and Selection

The cleaning and selection process offers numerous advantages in seed production. This process ensures the preservation of seed vigor, thereby enhancing the overall quality of the seeds. By removing other seeds, it improves the seed grade, leading to a more uniform and reliable crop. Moreover, maintaining purity is crucial in promoting the production of high-quality rice, as it prevents contamination by unwanted varieties or impurities. Additionally, the process helps prevent contagious diseases such as bakanae disease, ensuring healthier crops and greater yields. By increasing crop uniformity and health, it indirectly boosts productivity through improved crop performance. Furthermore, the adoption of mechanization and convenience in farming practices is facilitated by the consistency and quality of seeds produced through this process, ultimately streamlining agricultural operations.

3.2. Process of Seed Cleaning and Selection

The following is a diagram illustrating the detailed process of seed selection. From left to right, it demonstrates the sequential steps from inputting harvested seeds to packaging the final product on the far right.

〈Figure 3-3〉 South Korea's Seed Cleaning and Selection Process



Source: KSVS(2024c).

Firstly, rough selection refers to a preliminary sorting process before precise selection. Since large quantities need to be processed and stored in a short time, the priority is to remove relatively large impurities, sand, dust, and etc.

After rough selection, the next step is the drying process. This involves using heat generated airflow to dry the seeds to a moisture level suitable for safe long-term storage. For rice, the moisture specification is 14% or less. This drying process ensures that the seeds can be safely stored for an extended period. Once dried, the seeds are transferred to large storage bins (100 tons each) for storage. In the storage phase, it is crucial to maintain proper moisture and temperature to prevent deterioration in seed quality. This ensures that the seeds remain viable and healthy. Up to this point, we have covered the rough selection phase.

The following is the precise selection phase. Similar to the rough selection machine described earlier, but with greater precision, this sorting machine consists of 4 to 6 layers of sieves and is equipped with two fans to generate airflow. In the precise selection phase, seeds that do not meet the standards are meticulously removed. The next step is the disinfection phase. This process involves treating the

seeds with chemicals to protect them from seed-transmitted diseases and various pathogens.

Next is the packaging and loading phase. The seeds are packed into bags at a predetermined weight and sealed. These bags are then loaded onto pallets using automatic loading machines. KSVS operates packaging and loading using automated equipment. The packaging units are typically divided into 20kg and 5kg units for convenience and practicality.

After the product is finalized, KSVS continuously monitor the temperature of the grains and the humidity of the storage facility. KSVS maintain the optimal conditions in the storage warehouse until the product is supplied. To ensure the quality of the seeds during storage, KSVS conducts seed tests at least twice a month to assess any changes in quality.

After going through the final selection process for harvested seeds, we conduct seed testing. Seed testing is carried out according to ISTA Rules along with additional internal standards. This testing includes tests for variety purity, seed purity, germination rate, damage, and disease resistance. Seeds that meet the standards are guaranteed and ready for supply.

4 Conclusion

1. Summary

1.1. Summary

In Ghana, rice is the second staple food, and despite increasing demand, the country still imports a significant amount of rice. The government, in collaboration with various international organizations, has been formulating development policies and strategies for the rice sector to enhance food self-sufficiency. This study aims to review and supplement these policies, focusing on the low self-sufficiency rate due to the use of low-yielding rice seeds. The research objectives include proposing improvements to support policies and institutions, institutionalizing solutions to address hindrances in high-quality rice seed production, and identifying the current status and issues in rice production technology dissemination. The methodology involves literature reviews, field visits, interviews with stakeholders at various value chain stages, and commissioned research to analyze and develop policies for the rice sector. The research specifically analyzes the rice seed value chain and productivity improvement in the Dawhenya region.

The study found that Ghana's official seed production system is defined by quality management standards under the Ministry of Food and Agriculture, involving public research institutions and certified private companies. The seed certification system follows international standards, but issues like inconsistent certification levels, human errors, and improper storage/transportation were identified. Ghana implemented the "Planting for Food and Jobs (PFJ)" policy to increase food self-sufficiency and farmers' incomes, transitioning to PFJ 2.0 to enhance market operations by private entities. Major issues in the rice seed value chain include the use of low-yielding seeds, risks of counterfeit seeds, poor accessibility to government-certified seeds, inefficient supply chains, and a lack of information and market diversity for agricultural inputs.

1.2. Deriving Improvement Plans

Improvement plans were derived focusing on the production, certification, and distribution stages of the Ghana rice seed value chain. Firstly, for production stage, capacity building program for breeders would be helpful. For certification stage, strengthening seed quality management system, improving seed storage facilities, and establishing tracking systems can be applied. Lastly for distribution stage, enhancing public-private cooperation and promoting certified seed should be supported.

〈Table 4-1〉 Summary of Measures to Improve the Ghana Rice Seed Production Stage

Classification	Content
Strengthening the government's capacity to produce and distribute high-quality rice seeds	• Systematic support for government-certified seeds is necessary. - Verification if certified seeds are delivered to farms as planned is needed.
Capacity building for seed production farmers and companies	• Enhancing the capacity of breeders and farmers, including the transfer of modern agricultural methods, is necessary.

〈Table 4-2〉 Summary of Measures to Improve the Ghana Rice Seed Certification Stage

Classification	Content
Strengthening seed quality management system	• Developing and implementing strict quality standards: purity, milling quality, particle size, moisture content, and removal of contaminants. • Enhancing the capacity of quality management institutions and establishing a strict management enforcement system is necessary.
Improving seed certification and storage infrastructure	• Improving infrastructure (such as proper storage facilities) is necessary. • Modern laboratories for seed quality evaluation (e.g., genetic testing) are needed.
Establishing tracking systems	• Implementing a system that can trace seeds from the production stage to the consumption stage to ensure transparency in the supply chain.

〈Table 4-3〉 Summary of Measures to Improve the Ghana Rice Seed Distribution Stage

Classification	Content
Promoting certified seeds	• Promoting the benefits of improved certified seeds (new varieties and improved existing seeds) to encourage farmers to use these high-yielding seeds.

1.3. Directions for Korea-Ghana Cooperation

Currently, Ghana has relatively efficiently organized the seed distribution and market management system through the implementation of PFJ 2.0. However, overall infrastructure, including post-harvest management and storage facilities, remains outdated, and the conditions of laboratories for seed certification are particularly poor. Additionally, capacity building is needed across all stages of the value chain. To ensure the smooth operation of the new market system Ghana intends to implement, infrastructure development is essential, requiring substantial financial support. Furthermore, capacity building is necessary not only for farmers but also for government personnel, including public officials and researchers in seed certification laboratories.

Therefore, in terms of infrastructure development, the establishment of rice seed production complexes under the K-Ricebelt project is expected to address the infrastructure needs in the Dawhenya region. In addition to this, capacity building

through inviting Ghanaian experts and researchers for training in Korea, as well as dispatching Korean experts to Ghana, is necessary for enhancing human resources in seed inspection (field and laboratory tests). Moreover, providing farmers with detailed information on rice varieties through media promotions, such as model farms, brochures, and radio, is essential. Since the Ghanaian government collects farmers' demands for seed varieties to reflect in distribution policies, promoting new varieties when introducing them to the market is crucial. If the government lacks sufficient budget for such promotional activities, supporting promotional budgets can also be considered.

2. Policy Recommendations

In addition to the improvement measures detailed in the main text, the following supplementary policy recommendations are proposed. When institutionalizing policy support for the agricultural sector, it is important to consider the role and significance of the agricultural sector in the Ghanaian economy. In the case of Korea, various systems, such as electricity subsidies, have been established to protect agriculture. However, agriculture may not be a protected industry in Ghana. With a high proportion of agricultural production, Ghana may prioritize support for other sectors or may opt not to implement various protective measures to enhance agricultural competitiveness. Additionally, while rice is a staple crop in Korea requiring production support, it may not hold the same status in Ghana. If rice is a major food crop in Ghana, there may be a need to institutionalize support and protection measures for the rice sector.

As for policy recommendations, the following points are suggested. Firstly, there is a need for a subsidy system for agricultural electricity usage. To institutionalize national support for electricity usage, separate budget allocation and approval are

required. It is necessary to first determine whether this topic is suitable for public discussion. Additionally, considering support for solar power facilities to support self-generated electricity should be taken into account. Lastly, there is a Farmer Information Sharing System. It is important to distribute accurate information about rice to farmers, similar to what Korea's seed sources provide. This could be done through internet or text message notification services, providing information on webpages, mobile phones, and key seed information. Furthermore, notification services could inform farmers about the percentage decrease in yield of purchased seeds after 4-5 years, where to go for agricultural technology centers or companies to purchase seeds again, and what good seeds are. This information could be helpful to farmers.

Furthermore, it is proposed that the government take a leading role in managing rice seed and rice industries. Currently, the situation is such that the production and sale of popular varieties are left to the market, but rice is a difficult crop for private entities to profit from (due to high costs and the possibility of self-harvesting without the need to purchase seeds every year, among other reasons). If rice is an important crop in Ghana, it requires protection. Although the government adjusts prices through bidding, realistically, it's not easy to lower prices. Consequently, farmers may increasingly opt for self-harvesting instead of purchasing seeds separately, leading to a vicious cycle of decreased productivity.

Additionally, it is worth considering collaboration with Korea on the following aspects:

1. Establishment of large-scale production sites for popular rice varieties in each region: Priority should be given to land clearing and irrigation construction in regions where all 16 provincial agriculture departments are present, with an emphasis on achieving energy self-sufficiency.

2. Promotion of mechanized cultivation techniques: To secure competitiveness in rice production, the mechanization rate needs to be increased alongside related

technical education. While Ghana currently relies on manual labor for planting, methods such as direct seeding with machines (using seed drills) or using drones for direct seeding could be utilized.

3. Modernization of harvesting and drying facilities: Modernization of facilities is necessary to reduce post-harvest losses and enhance rice quality.

4. Training and establishment of quality management technologies for popular varieties: While Ghana has well-established rice-related regulations, implementation is hindered by a lack of manpower. Therefore, there is a need to train dedicated personnel, especially in quality management.

Collaborating with Korea on these initiatives could significantly contribute to the development of Ghana's rice industry.

Annexes

Annex 1. Field Visit and Interview(WUA)

□ Date and Location

September 14, 2023 (Thursday), 10:00~16:00, Dawhenya Region

□ Attendees

Gabriel Appentey (WUA Association Leader), Stephen Kwadjo, Ben Busumprah, Edna Attu, Rose Simtim (Farmers, Dawhenya Region), Alberta Martey, Navy Charllote Arcee (Local Rice Millers, Dawhenya Region)

Interpreters: Richard Marlej Aflel (FBO Association Head), Linda Esther Quartey (Plant Protection Regulation Officer), Kwasi Wih (Plant Protection Regulation Officer, Deputy Director)

□ Key Discussion Points

❍ Dawhenya Rice Production and Cooperative Status / Interviews with Cooperative Leader and Farmers

Total of 185 hectares of farmland, with 247 farmers having access to irrigation facilities. Government provides farmland to farmers free of charge, based on conditions such as participation in land development projects and existing property ownership. This land cannot be considered private property and is permanently allocated to beneficiaries. Consequently, elderly farmers may own land but are unable to farm, leading to unused agricultural land.

(Issues) Three main issues identified in the Dawhenya project area:

High electricity costs: The cooperative uses water pumps for irrigation, resulting in high electricity bills. Unlike Korea, there is no subsidy or support for agricultural electricity costs in Ghana. Additionally, there are no support systems for other management expenses (e.g., milling costs).

Low productivity due to poor quality rice seeds: Farmers face difficulty acquiring high-quality rice seeds. Most seeds used are self-harvested, resulting in low productivity. As rice demand in Ghana continues to rise, there is an urgent need for a steady supply of high-quality rice seeds.

Low mechanization rate: Rice is currently dried on the ground in Dawaynya, leading to increased post-harvest losses, especially during the rainy season. Farmers have requested drying machines and proper pest control facilities (instead of using fishing nets). They also need milling machines.

Farmers' Requests:

Need for more land: Mechanization is the most urgent need, but efficient mechanization is not possible without sufficient land.

Need for more farmer education: Despite efforts by the Ghana Ministry of Food and Agriculture to send officials for agricultural technology education, there is a severe shortage of officials compared to the number of farmers. Farmers are relying on self-study and mutual assistance to spread agricultural knowledge.

(Cooperatives) In Ghana, there are large-scale farmer cooperatives (Cooperatives) and smaller Water User Association (WUA) groups. Both must be registered with the government. The WUA groups are more active in the Dawhenya region. Members contribute fees to the WUA and use them to pay for irrigation, pump electricity, and shared facilities. However, even non-WUA members in Dawhenya can pay fees and use cooperative facilities. Farmers prefer to join cooperatives to sell crops at better prices. Additionally, a Revolving Fund is used to purchase seeds and fertilizers on loan, with each WUA managing its fund.

❍ Dawhenya Rice Production and Post-Harvest Management / Interviews with Rice Millers (Middlemen)

Middlemen play a crucial role in Dawhenya by receiving rice from farmers for milling. They can assess each farmer's production level as most farmers dry rice in communal areas. Due to prolonged rainy seasons, rice that would typically be dried outside is now dried indoors, increasing post-harvest losses.

All these processes incur costs, and farmers take loans from banks to cover them. However, some farmers with low yields struggle to repay their loans. This situation emphasizes the need for a continuous supply of good-quality rice seeds.

Rice quality could improve with better drying facilities and agricultural machinery (milling machines, separators). Farmers and middlemen are aware of the rice varieties circulating in Ghana, with most preferring aromatic varieties.

Interestingly, most middlemen are women, as men are reluctant to trade low-quality rice. High-quality rice is easier to sell, but there are numerous obstacles to selling low-quality rice. However, since most Ghanaian farmers are small-scale and produce low-quality rice, women remain as middlemen.

❍ Dawhenya Rice Production and Cooperative Status / Interview with Cooperative Leader

Q: Are there other cooperatives similar to those in Dawhenya in other regions of Ghana?

A: There are farmer cooperatives all over Ghana, mostly centered around irrigation facilities like the WUA. Upland farmers mainly grow vegetables, while lowland farmers use irrigation to grow various crops, including rice. JICA conducted a project that brought together cooperatives nationwide.

Annex 2. Joint(Commissioned) Research Guideline

(1) Dr.Maxwell Asante

Title : A Comprehensive Analysis of Rice Seed Production Systems in Ghana

1. Background on the importance of rice variety development and seed multiplication in Ghana's agriculture (Please state why developing rice seed production system matters in the current context.)

2. Scope and objectives

❍ The study will analyse the data demonstrating the trends and changes in Ghana's rice seed production systems, 2014-2023. It will identify social, economic, institutional, and technological barriers hindering research institutes and relevant private actors from producing sufficient high-quality rice seeds.

❍ The study will analyse the policies, regulations, and organisations producing and multiplying rice seeds of different generations (e.g., G0, G1, G2, R1) in Ghana. Thus, the analysis will help achieve the research objective of strengthening the institutional framework of rice seed production.

3. Methodology

❍ A literature review will be conducted to gather information on policies and institutional frameworks related to rice seed production (multiplication). Statistical data from the past decade will also be analysed to identify changes and transformations in seed production. Additionally, empirical data will be collected on the implementation of quality standards, certification processes, and the operation of seed testing laboratories.

❍ A descriptive statistical analysis will be conducted for rice seed production in regions with significant rice production.

❍ Semi-structured interviews will be conducted with key stakeholders to gather their opinions on current practices of producing rice seeds of each generation.

❍ An institutional analysis will be conducted to evaluate the effectiveness of policies, regulations, organisations, human resources, and the degree of collaboration with other critical stakeholders involved in the rice seed sector.

4. Analytical Tasks (Results)

❍ The Systems for Rice Seed Production in Ghana

❍ Provide a clear structure of the policies, regulations, and frameworks that govern rice seed production in Ghana. This should include an analysis of the linkages between policies, regulations, and the organisations responsible for producing rice seeds of different generations.

5. Situations, Conditions, and Opportunities

❍ How are rice seeds produced in Ghana through different channels, including government institutions and private companies? Please describe the detailed steps of producing each generation's rice seeds. Also, provide empirical data on rice seed production's current state or progress.

❍ Please state (i) the name(s) of organisations and (ii) the number of persons in charge of producing rice seeds for each generation. How do these organisations secure the budget for rice seed production?

❍ Please provide a brief outline and critical components of recent initiatives undertaken by the government to improve rice seed production systems. Also, specify the main factors of these initiatives' success or failure.

6. Threats, Problems, and Challenges

❍ Analyse the challenges of organisations or stakeholders responsible for producing rice seeds for each generation. Please provide relevant empirical data (e.g., the availability of seed storage and postharvest facilities throughout the country, the discrepancies between the seed demands and the quantity produced) to enable a close examination of these issues.

❍ Provide government costs related to producing (multiplicating) rice seeds of different generations and expenses assumed by other actors (e.g., private seed growers, research institutes, companies) with empirical data on an annual basis.

7. Institutional analysis

❍ Assess the effectiveness and efficiency of collaborations among government agencies, research institutions, extension services, and private stakeholders involved in producing rice seeds, if possible, based on empirical data or relevant evidence.

❍ Identify and highlight significant gaps in the institutional framework governing rice seed production.

8. Recommendations

❍ Please recommend short-term and long-term policies to enhance the production of high-quality rice seeds.

❍ Develop strategies and action plans to improve collaboration between government, research institutions, agricultural extension offices, and the private sector to increase the production of quality rice seeds and, ultimately, improve the quality of domestically produced rice.

❍ Please suggest an outline of a potential international cooperation project to enhance rice seed production systems in Ghana, addressing the current significant challenges and bottlenecks. The proposal should include specific types and con-

tent of capacity building, training, and awareness campaigns for public officials, seed growers, companies, and rice farmers.

(2) Kwasi Wih

Title: A Comprehensive Analysis of Rice Seed Quality Control Systems in Ghana

1. Background on the importance of rice seed quality management in Ghana's agriculture

2. Scope and objectives

❍ The study will analyse the data demonstrating the trends and changes in Ghana's rice seed quality management systems, 2014-2023. It will identify social, economic, institutional, and technological barriers that hinder the country's management of rice seed quality.

❍ The study will analyse the policies, regulations, and organisations involved in supervising and managing the quality of rice seeds in Ghana. The analysis will thus help to achieve the research objective of identifying the strengths and weaknesses of the institutional framework. It will also help the ultimate goal of this research, which is to suggest institutional interventions that can improve the quality of rice seeds supplied to end-users, particularly rice farmers in different regions of different socioeconomic conditions.

3. Methodology

❍ A literature review will be conducted to gather information on policies and institutional frameworks related to rice seed quality management. Statistical data from the past decade will also be analysed to identify changes and transformations

in quality management. Additionally, empirical data will be collected on the implementation of quality standards, certification processes, and the operation of seed testing laboratories.

- A descriptive statistical analysis will be conducted for seed quality management and distribution in regions where rice production is significant.
- Semi-structured interviews will be conducted with key stakeholders to gather their opinions on current practices of seed quality control.
- An institutional analysis will be conducted to evaluate the effectiveness of policies, regulations, organisations, human resources, and the degree of collaboration with other critical stakeholders involved in the rice seed sector.

4. The Systems for Rice Seed Quality Control in Ghana

- Provide a clear structure of the policies, regulations, and frameworks that govern rice seed quality management in Ghana. This should include an analysis of the linkages between policies, regulations, and the organisations responsible for quality management.

5. Situations, Conditions, and Opportunities

- How is the quality of rice seeds of each generation controlled and ensured by the Ghanaian government? Please provide empirical data on the current state or progress of quality control of rice seeds for each generation (e.g., G0, G1, G2, R1, R2). This should also include seed testing records and performances.
- Please state (i) the name(s) of organisations and (ii) the number of persons involved in overseeing the quality of seeds of each generation. How do these quality control organisations secure the budget for quality control?
- Please identify recent initiatives undertaken by the government to improve rice seed quality control systems. Also, specify the main factors of its success or failure.

6. Threats, Problems, and Challenges

❍ Analyse the challenges of organisations and stakeholders responsible for controlling rice seed quality.

❍ Provide empirical data on seed adulteration, contamination, and low germination rates to examine these issues.

❍ Provide government costs related to executing rice seed quality management systems such as inspections, tests, and certification, as well as inspection and certification costs for seed growers or companies, with empirical data on an annual basis.

7. Institutional analysis

❍ Evaluate the functions and obligations of various institutions directly or indirectly involved in managing the quality of rice seeds in Ghana.

❍ Assess the effectiveness and efficiency of collaborations among government agencies, research institutions, extension services, and private stakeholders in the rice seed sector based on empirical data or relevant evidence.

❍ Identify and highlight significant gaps in the current institutional framework governing the quality control of rice seeds.

8. Recommendations

❍ Please recommend short-term and long-term policies to enhance the quality management systems of rice seeds.

❍ Develop strategies and action plans to improve collaboration between government, research institutions, agricultural extension offices, and the private sector to ensure the circulation and use of high-quality rice seeds.

❍ (Optional) Advocate for increased budget and resources for seed quality management systems in Ghana, based on the analysis you conducted for this research.

❍ Please suggest an outline of a potential international cooperation project to en-

hance rice seed quality control systems in Ghana, addressing the current significant challenges and bottlenecks. The proposal should include specific types and content of capacity building, training, and awareness campaigns for public officials, seed growers, agro-input dealers, and rice farmers.

(3) Hassan Imoro

Title: A Comprehensive Analysis of Rice Seed Distribution Systems in Ghana

1. Background on the importance of distributing certified rice seeds in Ghana's rice production (Please state why a practical rice seed distribution matters in the current context.)

2. Scope and objectives

❍ The study will analyse the data demonstrating the trends and changes in Ghana's rice seed distribution/supply systems, 2014-2023. It will identify social, economic, institutional, and technological barriers that hinder rice farmers from accessing and using certified rice seeds in the country.

❍ The study will analyse the policies, regulations, and organisations supplying quality-ensured certified rice seeds for farmers in Ghana. The analysis will thus help to achieve the research objective of identifying the strengths and weaknesses of the institutional framework of seed and technology distribution.

3. Methodology

❍ A literature review will be conducted to gather information on policies and institutional frameworks related to rice seed distribution. Statistical data from the past decade will also be analysed to identify changes and transformations in seed

distribution. Additionally, empirical data will be collected on the implementation of quality standards, certification processes, and the operation of seed testing laboratories.

- ❍ A descriptive statistical analysis will be conducted for rice seed distribution in regions with significant rice production.
- ❍ Semi-structured interviews will be conducted with key stakeholders to gather their opinions on current approaches to distributing agro-inputs (rice seeds).
- ❍ An institutional analysis will be conducted to evaluate the effectiveness of policies, regulations, organisations, human resources, and the degree of collaboration with other critical stakeholders involved in the rice seed sector.

4. Analytical Tasks (Results)

- ❍ The Systems for Rice Seed Distribution in Ghana
- ❍ Provide a clear structure of the policies, regulations, and frameworks that govern rice seed distribution in Ghana. This should include an analysis of the linkages between policies, regulations, and the organisations responsible for distributing rice seeds.

5. Situations, Conditions, and Opportunities

- ❍ How are certified rice seeds distributed through different channels, including government institutions and private companies? Please describe detailed steps of delivering rice seeds. Also, provide empirical data on the current state or progress of certified seed distribution by region and by season.
- ❍ Please state (i) the name(s) of organisations and (ii) the number of persons involved in distributing rice seeds. How do these organisations secure the budget for seed distribution?
- ❍ Please provide a brief outline and critical components of recent initiatives undertaken by the government to improve rice seed distribution systems (e.g., PFJ 1.0, PFJ 2.0). Also, specify the main factors of these initiatives' success or failure.

6. Threats, Problems, and Challenges

❍ Analyse the challenges of organisations or stakeholders responsible for supplying certified seeds to farmers.

❍ Provide empirical data on estimated seed demand, the quantity of seeds supplied to rice farmers, and quality claims to examine the issues.

❍ Provide government costs related to distributing rice seeds, such as identifying and estimating local, regional, and national demands, aggregation, storage, bidding and selling, and transportation, as well as expenses assumed by private actors (e.g., seed companies, agro-dealers), with empirical data on an annual basis.

7. Institutional analysis

❍ Assess the effectiveness and efficiency of collaborations among government agencies, research institutions, extension services, and private stakeholders involved in supplying rice seeds and improving farmers' access to them, based on empirical data or relevant evidence.

❍ Identify and highlight significant gaps in the current institutional framework governing rice seed distribution.

8. Recommendations

❍ Please recommend short-term and long-term policies to ensure and improve rice farmers' access to certified seeds.

❍ Develop strategies and action plans to improve collaboration between government, research institutions, agricultural extension offices, and the private sector to increase farmers' use of certified rice seeds in different regions.

❍ Please suggest an outline of a potential international cooperation project to enhance rice seed distribution systems in Ghana, addressing the current significant challenges and bottlenecks. The proposal should include specific types and content of capacity building, training, and awareness campaigns for public officials, seed growers, agro-input dealers, and rice farmers.

(4) Samuel Tetteh

Title : Improving Farmer's Access to Agricultural Inputs and Technology: A Comprehensive Case Study

1. Background on the importance of improving local rice farmers' access to certified rice seeds in Ghana's agriculture (Please state why a practical rice seed accessibility matters in the current context.)

2. Scope and objectives

❍ The study will analyse the data demonstrating the trends and changes in Ghana's systems for improving local rice farmers' access to certified rice seeds and other agricultural inputs (ex. Fertilizer, Pesticides), 2014-2023. It will identify social, economic, institutional, and technological barriers that hinder rice farmers from accessing and using certified rice seeds in the country.

❍ The study will analyse the policies, regulations, and organisations supplying certified rice seeds to local farmers in Ghana. Thus, the analysis will help achieve the research objective of strengthening the institutional framework for farmers' access to improved agro-inputs and technology.

3. Methodology

❍ A literature review will be conducted to gather information on policies and institutional frameworks that ensure local rice farmers' access to certified rice seeds. Statistical data from the past decade will also be analysed to identify changes and transformations in rice farmers' access to seeds and improved agro-inputs.

❍ A descriptive statistical analysis will be conducted for the current state and progress of farmers' access to and use of certified seeds and agro-inputs in different rice production areas.

❍ Semi-structured interviews will be conducted with key stakeholders to gather their opinions on local farmers' current approaches to adopting certified seeds.
❍ An institutional analysis will be conducted to evaluate the effectiveness of policies, regulations, organisations, human resources, and the degree of collaboration with other critical stakeholders involved in the rice seed sector.

4. Analytical Tasks (Results)
❍ The Systems for Rice Seed and Agro-input Distribution in Ghana
❍ Provide a clear structure of the policies, regulations, and frameworks that govern rice seed and agro-input distribution in Ghana. This should include an analysis of the linkages between policies, regulations, and the organisations responsible for supplying certified rice seeds.

5. Situations, Conditions, and Opportunities
❍ How are rice seeds supplied to local farmers in Ghana through different channels, including government institutions and private companies? Please describe the detailed steps for farmers to achieve and use certified rice seeds. Also, provide empirical data on the current state or progress of rice seed distribution in major rice-producing areas.
❍ Please state (i) the name(s) of organisations and (ii) the number of persons in charge of supplying rice seeds in the local areas. How do these organisations secure the budget for rice seed distribution to local farmers?
❍ Please provide a brief outline and critical components of recent initiatives undertaken by the local government or other actors to improve rice seed distribution systems. Also, specify the main factors of these initiatives' success or failure.

6. Threats, Problems, and Challenges

❍ Analyse the challenges of organisations or stakeholders responsible for supplying certified rice seeds and agro-inputs to local farmers.

❍ Provide empirical data on estimated seed demand, the quantity of seeds supplied to rice farmers, and quality claims to examine the issues.

❍ Provide government costs related to supplying agro-inputs (especially, certified rice seeds) in local markets and expenses assumed by other actors (e.g., irrigation scheme managers, local agro-dealers) with empirical data on an annual basis.

7. Institutional analysis

❍ Assess the effectiveness and efficiency of collaborations among government agencies, research institutions, extension services, and private stakeholders involved in supplying rice seeds to local farmers, if possible, based on empirical data or relevant evidence.

❍ Identify and highlight significant gaps in the institutional framework governing rice seed distribution.

8. Recommendations

❍ Please recommend short-term and long-term policies to enhance local rice farmers' access to certified seeds.

❍ Develop strategies and action plans to improve collaboration between government, research institutions, agricultural extension offices, and the private sector to improve local farmers' access to and use of certified rice seeds.

❍ Please suggest an outline of a potential international cooperation project to enhance local rice farmers' access to certified seeds in Ghana, addressing the current significant challenges and bottlenecks. The proposal should include specific types and content of capacity building, training, and awareness campaigns for public officials, seed growers, companies, and rice farmers.

Reference

Asante, B.O., Frimpong, B.N., Asante, M.D., Prah, S., Ayeh, S.J., Sakyiamah, B., Zenna, N., Mujawamariya, G. and Tufan, H.A. (2023). Exploring Gender Differences in the Role of Trait Preferences among Stakeholders in the Rice Value Chain in Ghana. Sustainability, 15(7), p.6026.

Frimpong, B.N., Asante, B.O., Asante, M.D., Ayeh, S.J., Sakyiamah, B., Nchanji, E., Mujawamariya, G., Zenna, N. and Tufan, H(2023). Identification of Gendered Trait Preferences among Rice Producers Using the G+ Breeding Tools: Implications for Rice Improvement in Ghana. Sustainability, 15(11), p.8462.

MOFA(Ghana Ministry of Food and Agriculture)(2021), National rice development strategy (NRDS II: 2019 – 2030) (Draft). Ministry of food and agriculture. The Republic of Ghana.

MOFA- CSIR(2019). Catalogue of Crop Varieties released & Registered.

MOFA(2024), Planting for Food and Jobs Phase II (PFJ 2.0).

〈Online Source〉

GhAAP(https://ghaap.com/), Accessed: 2024. 3. 8.

CARD(https://riceforafrica.net/country_site/ghana/), Accessed: 2024. 3. 20.

〈Commissioned Research〉

Asante, M.(2023), Enhancing Rice Seed Systems: An Integrated Approach.

Imoro, H.(2023), Comprehensive Analysis of Enhancing Rice Seed Distribution System in Ghana.

Tetteh, S.(2023), Improving Farmer's Access to Agricultural Inputs and Technology: A Comprehensive Case Study.

Wih, K.(2023), Comprehensive Analysis of Enhancing Rice Seed Quality Control System in Ghana.

〈Internal Data〉

KSVS(Korea Seed & Variety Service).(2024a), "Production and Supply System of Nationally Certified Seeds", KSVS.

_____(2024b), "Quality Control Process of Seeds", KSVS.

_____(2024c), "Cleaning and Selection Process of Seeds", KSVS.